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DAYS

AT THE

FACTORIES;

OR,

THE MANUFACTURING INDUSTRY OF GREAT BRITAIN DESCRIBED,

AND

ILLUSTRATED BY NUMEROUS ENGRAVINGS OF MACHINES
AND PROCESSES.

SERIES I.—LONDON.

BY GEORGE DODD.

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DAYS AT THE FACTORIES.

I.—INTRODUCTORY CHAPTER ON THE TRADES OF LONDON.

The bulk of the inhabitants of a great city, such as London, have very indistinct notions of the means whereby the necessaries, the comforts, or the luxuries of life are furnished. The simple fact, that he who has money can command every variety of exchangeable produce, seems to act as a veil which hides the producer from the consumer. The coined piece of gold is the general agent, the factor, the broker, through whose medium the labours of all become available to all; and, like as in the case of other agencies, the principals have but a vague knowledge of the sources whence the supply is obtained. Who, if he were to catalogue the articles of food, or of clothing, or of furniture, or other commodities which contribute to his daily comfort, could enumerate the sources whence they are obtained, and the general character of the processes by which they are manufactured? The number of such is probably very small. And yet the inquiry is an interesting and a valuable one: for the social features of a city or town are largely dependent on these two questions,—whether manufactures are carried on therein to a notable extent, and whether the mode of production partakes more of the *factory* or of the *handicraft* character. Again, the means of transit from one town to another depend in a striking degree on the relative positions of the two towns with respect to manufactures: if each consumes largely the produce of the other, their mutual wants will not fail to lead to the construction of roads, of canals, of railroads, of shipping, and other facilities for transit; and these again give activity to various departments of commercial industry.

Selecting London—the busy centre of the commercial world—as the scene of inquiry, it may not be impracticable to take a rapid view of the chief departments of industry exhibited therein, so far as they come under the denomination of 'manufactures.' Among many different classifications of productive industry one might be adopted which should group manufactures under six comprehensive headings, according as they contribute to man's comfort in relation to *Food and Health—Clothing and Personal Ornament—Dwellings and Furniture—Instruction and Amusement—Means of Transit—and Means of Producing;* and in respect of all these branches of manufacture it may first be asked, Are they carried on in London less or more extensively than in the country? And next, Are they mere handicrafts, carried on by individuals of whom each one makes a complete article, or do they involve the investment of capital and the division of labour incident to a *factory?*

Beginning with the manufactures included under the first heading, we are at once struck with the difference exhibited between those relating to solid food and those relating to liquids; the former being mostly carried on in comparatively small establishments, while the latter involve arrangements of great magnitude. The London porter breweries, for example, are among the 'lions' of the metropolis, so vast are their dimensions, their vessels, their plan of operations, and the capital invested. Distilleries, too, exhibit the same remarkable largeness of feature; and Vinegar-works may be included in the same list. In all these three departments the metropolis confessedly takes the lead; and there seems reason to believe that a great magnitude of arrangement is in some degree indispensable to their profitable maintenance, for the number of such establishments, year after year, remains pretty nearly the same. Wine, as is well known, is not an English product, except in that humble degree which the term 'British' or 'home-made' wines indicates; and even this is much more of a domestic than of a manufacturing character. There are, however, two or three establishments in London which carry on this branch of manufacture to a much larger extent than the provinces can exhibit; and the like may be said of the beverage known as 'soda-water,' the production of which, and of other liquids bearing some analogy to it, involve mechanical arrangements more extensive than would generally be supposed, although insignificant when compared with some of those above noticed. Milk, of course, can hardly be deemed a manufacture, and London is placed similarly with other large towns in respect to its supply.

Turning to the more important subject of *solid* food, it will be found that scarcely anything deserving the name of a 'factory' is involved directly in the preparation of edibles. Our bread—whether in the form of 'four-pound' or 'two-pound,' 'cottage' or 'French,' 'brown' or 'wheaten'—goes through many hands before it is placed at our disposal, but does not involve large manufacturing arrangements. The mills which grind the corn can scarcely be said to exist in London at all; and the operations of the baker are carried on in his small 'bakehouse,' where two or three men can probably make all the bread for which he can find a sale. 'Metropolitan Bread Companies' have, indeed, at former times been started, with the object of manufacturing bread on a large scale: but these were among the commercial bubbles which burst soon after formation; and the only 'bread-factory' deserving of the name, near London, is the magnificent biscuit-baking establishment in the Victualling Yard at Deptford.

The animal food which forms so large a portion of general sustenance in London—whether fresh meat, or bacon, or hams, or eggs, or cheese, or butter, or fish—undergoes a very small amount of change—nothing, indeed, which can be denominated a manufacture in London, before it reaches the purchaser. The same, too, may be said of the large bulk of vegetable food. Sugar is one of the very few articles used as food which involve extensive manufacturing arrangements; but it is remarkable that sugar, as known to the mass of consumers, undergoes no process of manufacture whatever in England—a sugar-refinery having for its object merely the preparation of white, or 'lump,' sugar from the common brown 'moist.' Mustard is another article which requires tolerably extensive arrangements for its preparation; but mustard-mills are, we believe, more numerous in the provinces than in London. Pepper, salt, spices, sauces, pickles, preserves, and the thousand and one minor preparations which help to fill up the measure of modern table-luxury, all come under one of these two conditions: either they require nothing which can be termed manufacture, or they are manufactured out of London.

It may be deemed a misnomer to rank tobacco and snuff among articles pertaining to sustenance or health, but, wherever we rank them, they involve manufacturing arrangements of much ingenuity, of which London has a share at least equal to its importance among the scale of cities. This is perhaps scarcely the case with respect to those branches of manufacture which relate to drugs and chemicals: 'drug-mills' and 'chemical-works,' and manufactories, on a large scale, of commodities pertaining more or less to the medical art, are to be found in open spots of ground in the vicinity of London; but the North of

England may be deemed the principal theatre of these operations. The dentist, the 'artificial-eye' maker, the 'cork-leg' maker, the 'acoustic-tube' maker, and others who contribute by their manual dexterity to ease pain and sustain health—however valuable may be their labours—are manufacturers only on a small scale.

Glancing next at productive industry in respect of *clothing and personal decoration*, we cannot fail to remark these two facts—that the *factory* system is much more developed in this than in the former department of industry, and that London is but sparingly supplied with these factories. When we consider how large a portion of the modern attire of both sexes is formed of the textile fabrics—silk, cotton, linen, woollen, and worsted—and how small an amount of this is manufactured in London, we begin to appreciate the dependence of the metropolis on the country districts for a supply. Let a man enumerate the various articles which form his dress, and he will probably find that the woven and fulled material for his coat comes from the West Riding of Yorkshire, or from the West of England; that the linen for his shirt is of Irish manufacture; his gloves, if of silk, probably came from Derby, and his leather gloves from Worcester; to Nottingham he is indebted for his stockings, and to Glasgow for his 'Bandana' handkerchief. The materials for female dress, too, are dependent in an equally large degree on the labours of the provinces. In the district of which Manchester is the centre are produced enormous quantities of the various cotton fabrics, while Norwich contributes its crape, Derby its silks, Coventry its ribbons, Nottingham its bobbinet and machine-made lace, and Bedfordshire its straw-plait—omitting mention of the infinite variety of materials obtained from the Continent.

No one thinks of looking to London for a linen, a woollen, or a worsted factory; nor—although there is certainly one cotton factory in the metropolis—should we think of ranking cotton among its manufactures. With respect to silk, the circumstances are rather curious; for although a large quantity is manufactured at Spitalfields, yet it is here totally distinct from factory operations. The spun silk which is to form the warp and weft of woven fabrics is prepared in silk-mills, of which we believe there is not one in London. The humble handloom weaver of Spitalfields obtains the requisite quantity of warp and weft from the manufacturer, and works it up in his own poverty-stricken apartment, which often contains his loom, his bed, his kitchen, his family, and his birds and flowers (for the genuine Spitalfields weaver is a connoisseur in birds and flowers, under all his trials and difficulties).

But although scarcely any woven fabrics are produced in London (and those which are can hardly come within the class of factory produce), the arrangements for working up these materials into garments are here developed to an extraordinary extent. Tailors and dressmakers are to be reckoned, not by thousands, but by tens of thousands. So it may likewise be said in reference to boots and shoes, for shoemakers are among the most numerous of London artisans; but here another feature is observed, for the leather used in this manufacture is made in London more extensively than in any other part of England:—indeed the large district of Bermondsey derives its chief importance from its tanneries and leather-factories. We have no 'coat-factories' nor 'boot-factories,' no assemblages of men in large many-storied buildings, manufacturing coats and boots with those appliances of machinery and division of labour which distinguish a factory. Both are handicraft employments, which can be carried on at the home of the workman. There was at one time, during the last war, a shoe-factory strictly deserving of the name, established by Mr. Brunel for making shoes for the army by machinery; but taking it as a branch of national industry, shoe-making is almost independent of machinery.

To a man's *hat* the same remark cannot be applied as to his coat or his boots. The whole article is made from the raw material, and to a greater extent in London than anywhere else, by a connected series of processes in one establishment: the sheep's wool and the beaver's furry pelt are brought to London, and from these materials the glossy beaver hat is mainly formed by a chain of processes whose links have much of a factory character about them.

In what manner female labour is bestowed in making articles of dress is too well known to need recital. Here, from the Stepney seamstresses who wear out life by making shirts at a penny a-piece, to the court milliner who is surrounded by the luxuries of life, all produce their results by the slender needle and the supple thread, by dexterity of finger, by patience and endurance, and by such lengthened hours of labour as men would rebel against. In some few occupations, such as artificial-flower making, feather working, and so forth, other implements besides the needle and thread and scissors are required; but in the large bulk of female employments, as directed to dress, there is a singular uniformity of working apparatus, of posture, and of general procedure.

If we leave the textile materials of dress, and notice the various appendages and ornaments which modern taste deems indispensable to it, we find that a large number of manufactures at once come before us. The trifling *pin* which assists in the toilet, as well as the needle and the thread employed in making a dress, all come from distant parts of England. The pin, it is probable, was brought from Gloucestershire; the needle from Redditch; the sewing cotton and silk from Derby;—the manufacture of these articles being almost unknown in London. Then again, buttons and buckles, clasps and studs, hooks and eyes, and the numerous small articles of metal pertaining more or less to dress, are brought principally from the north. Those decorative appendages which remind us that 'all is not gold that glitters,' such as chains, guards, bracelets, rings, &c., are largely manufactured at Birmingham, as well as a portion of the really valuable jewellery: but it is probable that the larger portion of the gold, silver, and jewel manufacture, in its highest and most costly form, is carried on in London.

As an occupation closely connected with the manufacture of dress may be mentioned that of the dyer. This trade is not carried on in London on anything like the scale which the north of England exhibits, because all our woven fabrics are dyed before being consigned to the warehouseman in London, if not even before being woven. The chief dyers in the metropolis are those in Bermondsey who dye hats and leather, and those in various parts of London who re-dye partially worn articles of dress.

As cleansing agents in connection with the person and the dress, we must not forget soap, and soda, and pearl-ash, and blacking. All these are manufactured on what may be deemed a large scale, the first and the last principally in London. Indeed the other two are also largely made here, but they may be more appropriately associated with the north of England, especially since the changes which modern chemistry has wrought in the modes of producing these alkalis.

A glance may next be taken at some of the manufacturing operations by which our dwellings are built and stocked with useful furniture and implements. The raw materials, in this as in other cases, are brought from distant parts; the stone from Yorkshire or from Portland, or some other rocky district; the slate from Westmoreland or Wales; the timber from Norway or Canada; while the bricks and tiles are made in the fields in the neighbourhood of London. The bricklayer, the mason, the carpenter, the joiner, the slater,—all are artisans or handicraftsmen, in the usual meaning of these terms, and do not generally work together on anything like a factory system. Marble-working has within the last few years been brought under the operation of machinery, which in some degree sets it apart from the occupations just named. Glass-making has always been one of the most notable of our manufactures, and is carried on, in some of its branches, on a large scale in London; although window-glass and plate-glass are more extensively produced in the north of England. Saw-mills for timber have come prominently into use; but this can scarcely be called a branch of manufacture.

The painter is another whose labours must be classed here, as those of an artisan; but the preparation of his materials involves manufacturing arrangements of considerable magnitude, to some extent in London, and to a still larger extent in some other parts of England. Among such are white-lead works, colour works, oil and varnish works, and turpentine works.

When we turn our attention to the innumerable articles which come under the denomination of 'household furniture,' we find how largely the inhabitants of London are indebted to country manufacturers for the supply. Our carpets and rugs, our grates and fenders, our fire-irons, and the variety of implements and vessels made of iron and brass, found in every house, our plates and dishes, cups and saucers, knives and forks—all are brought from the north of England; or at least if any are made in London, the number is too limited to allow of these branches of manufacture being ranked among those belonging to London. Floor-cloth and paper-hangings are London manufactures, carried on in large premises, and by a routine of processes very similar throughout. The tables, the chairs, the bedsteads, the beds, the mattresses, the glass-frames, the picture-frames, the window cornices,—all are made to a vast extent in London, but not generally in large factories: they are the productions of tradesmen, each of whom can carry on a tolerably extensive business without great extent of room, or a large number of workmen. Clocks, time-pieces, and watches may perhaps be included in our present category. These are assuredly manufactured to a large extent in London; one entire district, that of Clerkenwell, being chiefly occupied by artisans in these departments of labour—some of whom, such as those engaged in the manufacture of church clocks, carry on their operations on a large scale. Yet even here we have a curious instance of the dependence of the London makers on the workmen of the north of England; for it is understood that the 'movement' or wheel and pinion work of almost every watch said to be made in London is actually produced in Lancashire, the London watchmaker being merely the workman who puts together the separate parts made by others. Proposals have recently been made to establish what might correctly be termed a watch factory; but up to the present time nothing has been known in London which can in any sense come under that designation.

Taking up next that item in our classification which relates to *instruction and amusement*, the mind at once dwells upon the printing-machine, and the agency by which it is brought to bear upon the spread of information, as occupying a prominent position in respect to this matter. Whether we regard the arrangements connected with the printing of a book, of a newspaper, or of parliamentary proceedings, London undoubtedly takes the lead among the cities of the empire. In no other British town or city are there printing-offices on so large a scale, or so many printing-machines congregated in one spot, or so many workmen contributing to this object by their combined exertions. Yet at the same time it is observable that the *paper* which is thus brought into useful requisition is not a London manufacture: there are no paper-mills in the metropolis, nor within several miles of it. The ink employed is made in London, but does not involve manufacturing arrangements on a large scale. The binding of books is, like the printing, a department of labour essentially metropolitan: there is probably no other town in England where the extent of book-binding is such as to warrant the construction and arrangement of a large building, on factory principles, for this purpose.

The number of occupations in London whose tendency is to contribute to the instruction and amusement of the inhabitants is extremely large; but it does not appear that many large manufacturing arrangements are involved in them. Take, for instance, a pair of globes, a case of drawing instruments, a telescope, a microscope, a set of instruments used by the surveyor—all these require mechanical ingenuity of a very high order; but it is the ingenuity of the individual workman, who could exercise his vocation as well in a small room as in a large factory, and perhaps better. The implements and instruments employed in scientific investigations of every kind are similarly dependent, for their production, on manual dexterity, and not on factory combinations; while those conducive to education, in schools, mechanics' institutions, colleges, and universities, are still less complex than the others.

Amusement, like instruction, presents one prominent instance wherein factory arrangements on a large scale are involved. *Books* and *piano-fortes* are each, in London, produced on a scale which totally eclipses the productions of the provinces. Nay, there is perhaps not one occupation, throughout the whole range of productive industry, in which the metropolis maintains a more marked pre-eminence than in the manufacture of piano-fortes; for these instruments are classed among those wherein a kind of commercial halo envelops the names of the principal manufacturers. This preference for London-made instruments, and the spread of musical taste within the present century, have led to factory arrangements on an extremely large scale in reference to piano-fortes.

Other musical instruments are manufactured to a much humbler extent. Organs, indeed, from their large dimensions, require corresponding arrangements for their manufacture, which bears considerable resemblance to that of a piano-forte in many parts. Harps, guitars, violins, violoncellos,—all require more delicate skill than extensive arrangements for their production; and the same may likewise be observed of wind instruments made of wood, such as the flute, the clarinet, and the flageolet; and those made of brass, such as horns, trumpets, and bugles. Tube-drawing and cylinder-boring form steps in the manufacture of many of these instruments; but the finishing processes which follow are examples of delicate manipulation, generally carried on in small workshops.

If we turn from music to the drama, we find certainly extensive mechanical arrangements involved in the economy of a theatre; but these are of course only appliances, to this particular purpose, of departments of labour properly classified elsewhere. The carpenter uses the same materials and works in the same manner as another carpenter; so the scene-painter; so the tailor.

With respect to those departments of study pertaining to the fine arts of architecture, sculpture, figure-casting, painting, and engraving, the mental so far overpasses the mechanical as to take them almost out of our present enumeration. The architect merely requires, from the artisan and the manufacturer, his paper and drawing-board, his case of instruments, his rulers and squares, and then draws upon his own mind for other working materials. The sculptor has his mallet and his chisels, and has perhaps Behnes' machine aiding him in copying his model, and he may wear an apron or a rusty coat in his studio; but the brains effect more than the fingers in his daily labour. In figure-casting, it is true, the operations are nearly analogous to those of a common foundry, or a bell foundry, so far as regards the treatment of the melted metal; but the preparation of the model, buried within the sand or clay, is a work of high art. The same may be said of the neat plaster figures vended so largely by the itinerant Italians: the manufacture is conducted in a number of small establishments in the neighbourhood of Hatton Garden; but the original figures—by whatever agency copied, and to whomsoever belonging—must have been the result of a sculptor's labours. The engraver uses his engraving-tools, and his etching-tools, and his aquafortis for 'biting in,' and is so far dependent on the labour of manufacturers; but the mental character of his own operations is sufficiently apparent. The painter, or "artist" in the general English acceptation of the term, is perhaps more indebted to artisans for the preparation of his materials than any of the other parties mentioned in this paragraph. There are several tradesmen, denominated 'artists' colourmen,' who, in the preparation of primed canvas, card-board, oil-colours in bladders, water-colours in cakes, brushes, pencils, palettes, easels, &c., carry on a tolerably busy circle of operations. But these various articles are rather a collection of component parts, procured from workmen in various quarters, and brought into a saleable form, than the result of a uniform system of manufacturing.

Descending from the professor of the fine arts to the child, we find that toys give rise to no inconsiderable amount of manufacturing enterprise. The ball and the bat, the whistle and the drum, the rocking-horse and the mimic cart, the hoop, the doll, the humming-top, the skipping-rope—all are sold so very largely as to render the employment of a considerable number of persons necessary to the maintenance of the supply. A wholesale toy warehouse would surprise those who for the first time were to visit it, by the magnitude of its arrangements, the classification of its contents, and the indication which it affords of the importance of trifles when large in number. But although the warehousing is thus extensive, the manufacture of these articles is not conducted in large factories. The dealer collects his store from a large number of persons, each of whom, perhaps in a very humble dwelling, fashions some of the numerous kinds of children's toys; the little fragments of wood, of coloured paper, of leather, of tinsel, which enter so largely into the construction of these humble articles, are cut out and prepared principally by children,—indeed the price at which the toys are sold sufficiently indicates that the wages of labour in their manufacture must be insufficient for adult workmen, except in the better kinds of toys. Could we dive into the alleys and narrow streets at the east end of London, we should probably find many whole families—father, mother, and children—employed in making toys under their own poor roof; but a toy-factory, properly so called, does not perhaps exist in London.

Leaving now the manufacturing operations conducive to the instruction and amusement of various classes, we may walk abroad, and see what manufactures have done in furnishing us with *means of transit.* What do our streets present in this respect? In the first place the pavement—one of the prides of London—exhibits the contest now going on between stone, wood, and bitumen: the first has nearly succeeded in resisting the inroads of the third, but seems to be gradually yielding to the second. No longer do we see, except in the minor streets, the shapeless pebbles or rounded stones which used to form the carriage-way: 'dressed. granite' has superseded them; while the foot-pavement exhibits its broad flag-stones, ranged with perfect regularity, and having just such a slope as will carry off rain-water. Then again the wood-pavement:—here we have hexagonal prisms; in another place small cubes; in a third larger cubes; in a fourth blocks whose shelving sides form bonds of union with each other; in a fifth cakes of blocks pinned together, somewhat resembling (if such a simile be pardonable) a batch of rolls from a baker's oven. The bitumen, too, exhibits much of the care now bestowed on our roads and pavements, in its arrangements for producing a level and durable surface. All these, however, can scarcely be deemed branches of manufacture: they are applications of manual labour in a very rough and unpolished form, aided by few buildings, few machines, and few tools. The saw-mill which shapes the blocks is perhaps the nearest approach made to factory appendages or operations.

When we see how our streets are lighted, and the aid which the passenger and the traveller derive from this most brilliant of modern improvements, we can scarcely fail to remark how manufactures in this instance facilitate the means of transit; for gas is, in the proper sense of the term, a manufacture carried on in London to a vast extent, and involving works and systems of operation as ingenious as they are important. The oil-lamps of bygone days, though they befriended the whale-fishery, could scarcely be said, as in the case of gas, to be connected with manufactures.

From the lamps which illuminate our streets, we turn to the vehicles which traverse them; and here we find a very conspicuous department of London manufacture. Coach-making is carried on in the metropolis to a greater extent, and probably in a higher style of excellence, than any where else. From the light gig to the state-coach, from the cab to the four-horse stage, from the small cart to the heavy waggon, all are manufactured here; and in one part of London several establishments are congregated, in which the classified arrangement of operations is very complete. The wheels of vehicles, too, form another extensive branch of manufacture; as do likewise the varieties of harness and trappings. Whips, again, furnish employment to a considerable number of workmen. These latter, as well as the artisans who furnish pedestrians with walking sticks, umbrellas, pattens, and clogs, are generally tradesmen on a small scale.

If we view the means of transit out of London, we find that, in addition to the manufacturing aid just alluded to, there is scarcely any but what comes rather under the head of engineering than manufacture. The formation of common roads, of paths, of bridges, of viaducts, of tunnels, of embankments, of excavations, of railways—all form part of the important profession of civil engineering. It is true that bricks must be made, stones dressed, mortar and cement mixed, and iron rails formed; but these are, individually, instances of manufacture which come under some other head of classification.

Passing from the land to the sea, we at once perceive that the means of transit involve manufacturing arrangements of a very remarkable kind. A ship is one of the noblest productions of men's hands, and a ship-yard one of the most extensive of factories. London shares with Sunderland, Glasgow, Liverpool, and other ports, in the possession of such establishments. The fine vessels for the East India trade have been all along made principally in the Thames; and an extensive portion of other shipping has been also made there. The ships of war, and

Government ships generally, used formerly to be made occasionally in private yards; but they are, we believe, now wholly made in the Royal Dock-yards.

Many of the fittings of a ship involve large branches of manufacture, such as ropes and cables, chain-cables, anchors, sail-cloth, &c.; and these furnish employment for extensive establishments at the east end of London: but masses of iron-work, though manufactured in London, are not associated with it as a branch of labour so much as with South Wales, Butterley, Rotherham, Dudley, the Carron, and other well-known places in the north. The same may perhaps be said of marine steam-engines and boilers, for the making of which there are a few establishments in London, but probably more in the busy districts of the north.

Lastly, a glance may be taken at a department of productive industry which, for want of a better term, we will call *means of working* or *working agents*, and which will include a varied assemblage of machines, engines, implements, instruments, tools, and vessels. These are, in fact, the means of which we avail ourselves in producing all the commodities included in the preceding five headings, but which could scarcely be included among the commodities themselves. For instance, although we rank the refining of sugar among the branches of manufacture pertaining to food, yet the manufacture of the sugar-pans, the clarifying vessels, the charcoal cisterns, and the other apparatus indispensable to the refining of sugar, must find a place somewhere. So likewise, though the painting of a piece of floor-cloth may be ranked among London manufactures relating to household furniture, yet the making of the loom which wove the canvas must evidently be classed in some other group. In a multitude of similar cases we shall find it convenient to appropriate a place in some large and distinctive class for the kind of power which enables us to produce commodities belonging to the other classes.

Now we shall find that the making of these machines and tools generally resolves itself into a department of 'manufactures in metal,' and that, generally speaking, it is a manufacture pertaining to the northern and midland districts of England rather than to London, although many large establishments of the kind exist in and around the metropolis. Steam-engines for manufacturing purposes are in our own day most largely produced, involving arrangements and apparatus of a gigantic kind. The machinist and the millwright in like manner now consume vast quantities of iron and steel in the fabrication of the numerous machines which are in their turn to become producers. The circumstance of the cotton manufacture having become so firmly located in Lancashire has exerted a powerful influence on the settlement of machinists, millwrights, and engineers in that quarter; otherwise, London would perhaps still have maintained a pre-eminence in these departments.

A 'machine-maker' is not, as a simple designation, sufficient to explain the avocation of a manufacturer; except perhaps at Manchester, where power-looms and spinning machinery take the precedence of every thing else in respect of machines. In London, for instance, the manufacturers who produce a printing-machine may never have made a fire-engine, or a beer-engine, or a mangle; nor could the makers of these produce the former, without introducing entirely new arrangements into their establishments.

The manufactures in metal are, it may be observed, carried on in London generally on a smaller and more divided scale than in the north, especially those which relate to iron and steel. Vicinity to the coal districts affords a mode of accounting for this circumstance. Copper is worked largely in London, and so is lead; both metals are so malleable and ductile, that a larger proportion of the manufacturing processes can be effected without heat than in the case of iron. The sheet-lead for roofs and terraces, lead tubes for water-pipes, copper vessels for brewing, distilling, sugar-refining, steam-boilers, &c., are all manufactured to a considerable extent in the metropolis. The mixed metals, such as brass, gun-metal, bell-metal, and fusible metal, are all worked up into useful forms here, but generally in establishments of no great extent.

When we come to notice agricultural machines and implements, tools for carpenters and artisans generally, and other mechanical aids which give increased power to manual labour without the aid of steam, we shall probably find that there are but few to which Sheffield and other towns of the north have not contributed. The tool-makers and machinists of London have such facilities in obtaining supplies from the midland counties, that in most cases the London work consists mainly in putting together various pieces of metal fashioned there. The saws, the nails, the screws, the plane-irons, the chisels, the files—scythes, harrows, plough-shares, rakes, spades—all emanate from the north, generally in a rough state, and are merely finished and adapted by the workmen in London. Of the various species of cutlery, most of the bulky and coarser kinds come from the same districts; but fine cutlery is produced in London, although not in large establishments.

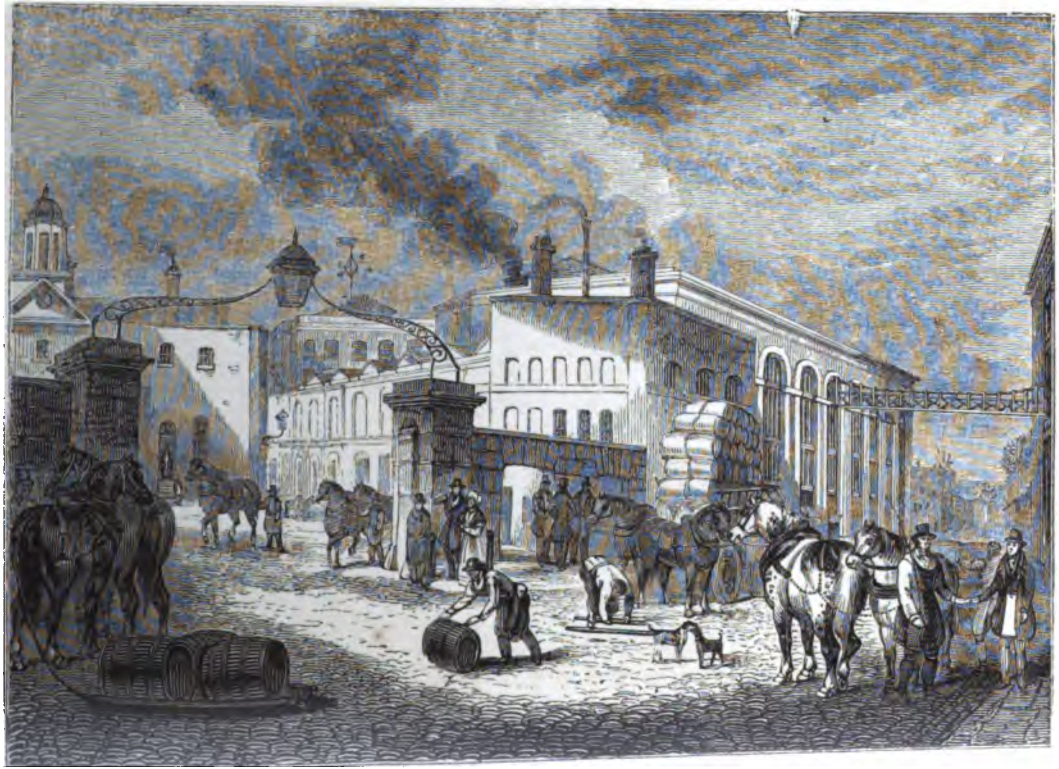
As we have included vessels among the means of facilitating manufactures, we may briefly remark that those of wood are the produce generally of small manufacturers,—the wooden vats for brewers being perhaps those which require the largest manufacturing arrangements. Tin culinary vessels are also produced in considerable number in minor establishments. Brown-stone ware or coarse earthenware vessels are made somewhat extensively in Lambeth; but Staffordshire and Derbyshire are the districts to which we are accustomed to associate every department of the pottery manufacture.

Whoever were to attempt to classify all the trades and occupations of London, and were to consult a directory with a view to determine their number, would perhaps be somewhat startled to find it amount to something like thirteen or fourteen hundred, and would admit that any classification of them under five or six headings must necessarily be very imperfect. It is not pretended that the arrangement given in the preceding pages is anything more than an approximate aid, or that we have glanced at more than the chief in each class; but it may perhaps have been shown that, numerous as are the London trades, the number which involve large factory arrangements, and are *characteristic* of London, is not so considerable as would at first appear.

In the following pages an attempt is made to convey some idea of the general character of a few of our London manufactures, in the form of 'visits' to certain specified establishments, the general arrangement and internal economy of which are described, as a means of illustrating more distinctly the manufacturing details. The departments of manufacture selected are such as, in most cases, pertain to London rather than to the country, and are conducted on a scale sufficiently large to involve something like 'factory' arrangements. The general character of the processes is sketched, in a form which does not aim at the completeness and technical minuteness of a Cyclopædia or practical treatise, but which, it is hoped, will convey information to those who, although not engaged in these manufactures, would like to know by whom, and from whence, and in what manner, the familiarly known commodities of life are produced.

The means of effecting this would have been wanting had not the proprietors of the respective establishments liberally afforded facilities for inspecting the processes of manufacture, and taking drawings to illustrate them. Those gentlemen will, perhaps, at the outset, accept the best thanks of all concerned in the production of this volume for their courtesy.

[The greater number of these articles have appeared in 'The Penny Magazine;' but so general a wish has been expressed for their republication in a separate form, that, the author having carefully revised them, they are now given in a compact shape, forming an acceptable volume for young persons especially. The original papers have been extensively used in the higher classes of schools, amongst others in the Engineering class of King's College.]



II.—A DAY AT A BREWERY.

THOSE dwellers in and visitors to the 'Great Metropolis' who cross Southwark Bridge from the City to the Borough can scarcely fail to have observed the array of tall chimneys which meets the eye on either side of its southern extremity; each one serving as a kind of beacon or guide-post to some large manufacturing establishment beneath—here a brewery, there a saw-mill, farther on a hat factory, a distillery, a vinegar factory, and numerous others. Indeed, Southwark is as distinguishable at a distance for its numerous tall chimneys and the clouds of smoke emitted by them, as London is for its thickly-congregated church-spires. Let the reader, when next on the bridge, single out from among these chimneys one more bulky, though not more lofty, than the rest; and this will point out the spot where one of those gigantic establishments—a London Brewery—is situated; establishments which, whether we regard the extent of the buildings comprising them, the amount of invested capital by which they are maintained, or the systematic arrangements by which the daily operations are conducted, rank among the first in the kingdom, or indeed in the world. Without entering into the chemical niceties which are involved in the process of brewing, or into a history of beer and malt liquors generally, we hope to convey to the reader some idea of the astonishing magnitude of the arrangements and the labour by which a 'pint of porter' is produced.

On crossing Southwark Bridge to the Surrey side of the water, the Bridge-road passes over a narrow street running parallel with the river, to which we descend by a flight of stone steps; and on looking eastward along this street, we observe large ranges of buildings on either side, connected by a covered bridge or passage thirty feet from the ground. These piles of buildings form parts of the brewery of Messrs. Barclay and Perkins; and on approaching the end of the right-hand range, we arrive at another street leading southward, both sides of which are in like manner occupied by the brewery buildings, extending to a distance of several hundred feet. Proceeding southward along this street, we pass under a light and elegant suspension-bridge, by which communication is established between the opposite sides; and beyond this we arrive at the entrance to the brewery, within which are two or three open yards or squares, surrounded by buildings of vast extent. The engraving represents some of the principal buildings of the brewery, together with the suspension-bridge, taken from a spot nearly opposite the principal entrance. The entrance gate is large and elegant, and fronting it is a building appropriated as offices and counting-houses, where thirty or forty clerks are employed.

Nearly in the middle of the premises is a building, called the 'tun-room,' in which some of the processes connected with the brewing are conducted; and from the leaded roof of this building we obtain a panoramic view of nearly all the various parts of the brewery. Towards the north-east, on the river side, is a wharf, from whence beer is shipped for exportation; to the north are two large ranges of malt-warehouses, separated by the street first alluded to, and connected by the covered bridge; westward is an open court, containing at various points in its circuit an engine-house with all the steam-engine apparatus, two water-reservoirs for the supply of the establishment, a cooperage, a building where casks are cleansed, sheds for containing empty casks, and various other buildings: southward is a most extensive range of storehouses, where the beer is kept in vats; and beyond these is a range of stables for the dray-horses: to the south-east is the fining-house and some of the storehouses; and, lastly, eastward are the porter and ale brewhouses, connected by the suspension-bridge passing over a street below. Such are the extensive ranges of buildings visible from the elevated roof of the 'tun-room;' the whole covering a space of ground eight or nine acres in area, and from a quarter to a third of a mile in circuit.

The purposes to which these several buildings are applied will perhaps best be understood by following the processes in the order actually observed in the brewery; by tracing the water, malt, and hops through their successive changes, as far at least as may be done without discussing the scientific details of the processes.

The water used for brewing is that of the river Thames, pumped up by means of a steam-engine through a large iron main; the main passing under the malt-warehouses, and leading to the reservoirs in the open court of the brewery. The appellation given to these cisterns reminds us of the fact that every manufacture has its peculiar phraseology, not easily understood by strangers: for when we hear mention made of the 'liquor-back,' it requires some explanation to show that this is but another name for 'water-reservoir;' water, in the language of the brewhouse, being 'liquor,' and a cistern or reservoir a 'back.' Into these cisterns, then, the water is conveyed; and we have seldom seen a cast-iron structure present a finer combination of strength with elegance. Fifteen iron columns, each nearly half a yard in diameter, are ranged in three rows of five each; and on the top of these columns is the lower cistern, a cast-iron vessel about thirty-two feet long by twenty wide, and several feet deep. From this cistern rise the supports by which a second one, about the same size as the former, is upheld; and a light staircase leads up from the ground to the upper cistern. The whole structure, reaching an elevation of probably forty feet, is made of cast-iron.

By these means, then, the establishment is supplied with a reservoir of water for brewing, the water flowing into the various vessels from the cisterns by the usual kinds of apparatus; and the importance of these arrangements may be judged from the fact that a hundred thousand gallons of water, on an average, are required for the services of the brewery every day. There is a well on the premises, not far from the cisterns; but the water obtained thence is employed principally, on account of its low temperature, to aid the cooling of the beer in hot weather.

All the pumps by which the water is conveyed from the Thames to the cisterns and from the cisterns to the brewing-vessels, as well as various machinery used in the brewhouse, are worked by a steam-engine situated near the water cisterns. There are two engines; one of forty-five and the other of thirty horse-power, used together or separate according to the extent of operations at different times. The construction of these engines, and the mode in which power is communicated from them to various parts of the establishment, resemble those generally observed in large factories, and need not claim particular notice here.

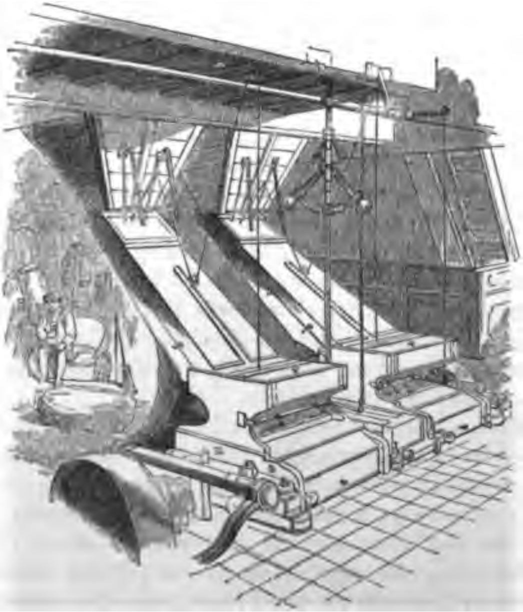
A visitor's attention may next be directed to the malt, and the means by which it is conveyed to the brewing buildings. On looking from the great brewhouse towards the river he will probably be struck with the appearance of a string of sturdy porters, each carrying a large sack on his back from a barge at the river-side to the malt-warehouses. These men follow each other pretty closely, each one bringing his sack of malt, weighing about one and a half hundredweight, from the barge, depositing the contents in the warehouses, and returning to the barge with the empty sack. If the malt-warehouses extended to the river, the bags or quarters of malt would probably be hauled up by crane and pulley from the barge lying beneath; but premises unconnected with the brewery intervene, and consequently the services of these malt-porters are necessary. Each man carries his bag of malt into the warehouse, up several flights of stairs, and empties the contents into one of a series of enormous bins or boxes. These bins, which are about two dozen in number, are of such extraordinary dimensions, especially in height, that we may say, without exaggeration, that an ordinary three-storied house,—roof, chimneys, and all,—might be contained and shut up in one of them. They are formed entirely of wood, and are supplied with malt till full; the earlier portions of the supply being introduced at a door half-way up the bin, afterwards closed up.

As the northern malt-warehouse is separated by a street from the brewery buildings, the malt originally deposited there is, when wanted,

conveyed from the north to the south warehouse by an arrangement of a very curious kind. At the lower part of the front of each malt-bin is a little sliding door, eight or ten inches wide and rather more in height, which, when slid upwards, allows the malt to rush out with great quickness; and at these doors another set of malt-porters, such as are represented in the cut in page 20, are employed whenever the malt is to be transferred from the north to the south warehouse. Each man brings a basket covered with leather, and capable of holding about two bushels, to a shelf or stage beneath the sliding door; opens the latter; fills his basket with malt; takes it on his back by means of a strap held in the hand, and carries it to a large funnel or 'hopper,' into which he empties the malt. In this manner each man will frequently carry four hundred loads in a day, of two bushels each, from the bins to the funnel; and as all the men deposit their loads of malt in the same funnel, it is natural to look to this as the immediate channel of communication. Dipping into this funnel is an apparatus called, in the language of the brewery, a 'Jacob's ladder,' consisting of an endless leather band, passing round rollers at the top and bottom, and carrying a series of tin buckets, each capable of holding about two quarts. As the band travels vertically up and down, each bucket in turn dips into the malt, becomes filled, travels upwards to the top of the building, and empties its contents upon a canvas cloth: the buckets are thus, in fact, substitutes for porters, each one in turn conveying its two quarts of malt up to the top of the building.

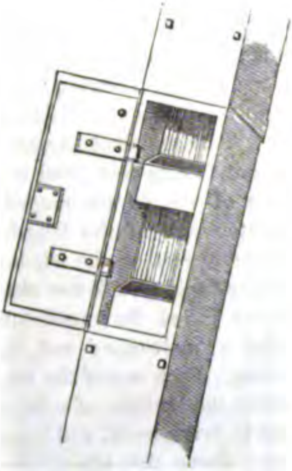
The cloth on which the malt is emptied is stretched across the street from the north to the south malt-warehouse; and, to understand its action, we must beg the reader (claiming pardon for the homeliness of the simile) to imagine a jack-towel passing horizontally across the street, and stretched over rollers at the two ends. Each little bucket pours its contents on the upper stage of this towel or cloth, which is called a 'carrier;' and the deposited heaps travel from the north to the south warehouses, the lower stage of the cloth at the same time returning empty in the opposite direction. The covered passage containing this cloth or 'carrier' is that which meets the eye when looking eastward from the Southwark-bridge Road; and it was by this passage that we crossed from the north to the south malt-warehouse.

Having thus traced the malt in its progress from one warehouse to the other, we next watched its preparation for the brewing processes. The malt which had been originally deposited in the bins of the southern warehouse, as well as that which is brought from the northern, is emptied into one common funnel or 'hopper:' the former being brought in baskets by another set of malt-men from the bins, and the latter flowing down a pipe from the endless 'carrier' cloth. From this funnel the malt descends through a pipe into a lower receptacle in the mill or grinding-room, and is taken up by a second 'Jacob's ladder' to a hopper, or receptacle in the upper part of the mill-room, from which it descends into one or other of the grinding (or, rather, crushing) machines represented in the subjoined cut. Each of these machines contains a pair of steel rollers rotating nearly in contact, by passing between which the malt becomes crushed into the state called *grist*. This grist may have any degree of fineness suitable for the kind of malt-liquor to be produced, by regulating the distance between the rollers.



A third 'Jacob's ladder,' much larger than either of the others, carries the grist from the grinding-room to a height of sixty or seventy feet in the middle of the great brewhouse and near its roof;

where the grist is deposited in various channels, of which we shall have to speak presently. The stages or layers of these 'Jacob's ladders,' or, rather, the ascending and descending ladder, are each enclosed in an iron trunk or case extending the whole length; the ascending ladder having the buckets full, while those of the descending ladder are empty. The subjoined cut shows the appearance of two of the buckets seen through an open door in the iron case. The buckets and the endless leather band to which they are attached are set in motion by machinery connected with one or both of the rollers at the ends of the ladder; and when we state that these buckets raise up, on an average of the whole year, more than two thousand two hundred quarters of malt per week (for this is the quantity required for the brewery), it will be allowed that this 'Jacob's ladder' is a most industrious porter.



Of the great brewhouse itself, to which we have now arrived, it is no easy task to give a description. The first effect on the mind of a stranger is a state of bewilderment, which is not removed till matters are viewed a little more in detail. The dimensions of the room are so vast, the brewing utensils reach to such a height, and the pumps, pipes, rods, and other apparatus are so thickly arranged on every side, that unless we follow the actual brewing processes in their regular order, the whole assemblage, to the mind of a visitor, becomes a mass of confusion.

In the first place the reader must imagine a room nearly equalling Westminster Hall in magnitude, built entirely of iron and brick, and uninterrupted by distinct floors or partitions, so as to be open from the ground to the roof, except where stages and platforms occur in various parts and at various heights. The room is lighted by eight lofty windows on the east side; and all round the walls just below the roof are openings for the exit of steam. The principal part of the room is occupied by ten enormous piles of brewing vessels, reaching from the ground to a great height. Without troubling ourselves with detailed measurements, it will be sufficient to state the average diameters of all these vessels at about twenty feet; and the arrangement of them is as follows:—The piles of vessels are ranged in two rows of five each, occupying the greater part of the length of the room, parallel with the windows. Those nearest to the windows consist of a square iron vessel called an 'under-back' (*i. e.* lower cistern), near the ground; above this a circular vessel called the 'mash-tun;' above this again a square wooden box called a 'malt-case;' and, highest of all, a pipe to convey malt into this case. Each one of the set farthest removed from the windows consists, near the bottom, of a large furnace; above this, a copper-boiler enclosed in brick-work, and capable of holding nearly twelve thousand gallons; above this again, a vessel called a 'copper-pan;' and at the top a 'copper-back,' for receiving the wort previous to its being boiled with the hops. These ten piles of vessels, as before stated, occupy the chief part of the brewhouse; but there is also, near each end, a very capacious square vessel, called a 'hop-back,' or 'jack-back.' The pumps, pipes, iron platforms, iron flights of stairs, &c. are very numerous, and distributed in various parts of the building; but they are altogether subsidiary to the large piles of vessels just alluded to.

Let us now see how far it may be practicable to explain, in a brief manner, the purposes to which these huge vessels are applied. To aid the description, we give a sectional representation of the principal vessels and working apparatus. The reader is supposed to be looking southward, with the windows on the left hand, and to have before him a vertical section of all the vessels in one of each of the five pairs alluded to above, together with the long 'Jacob's ladder,' and the malt-

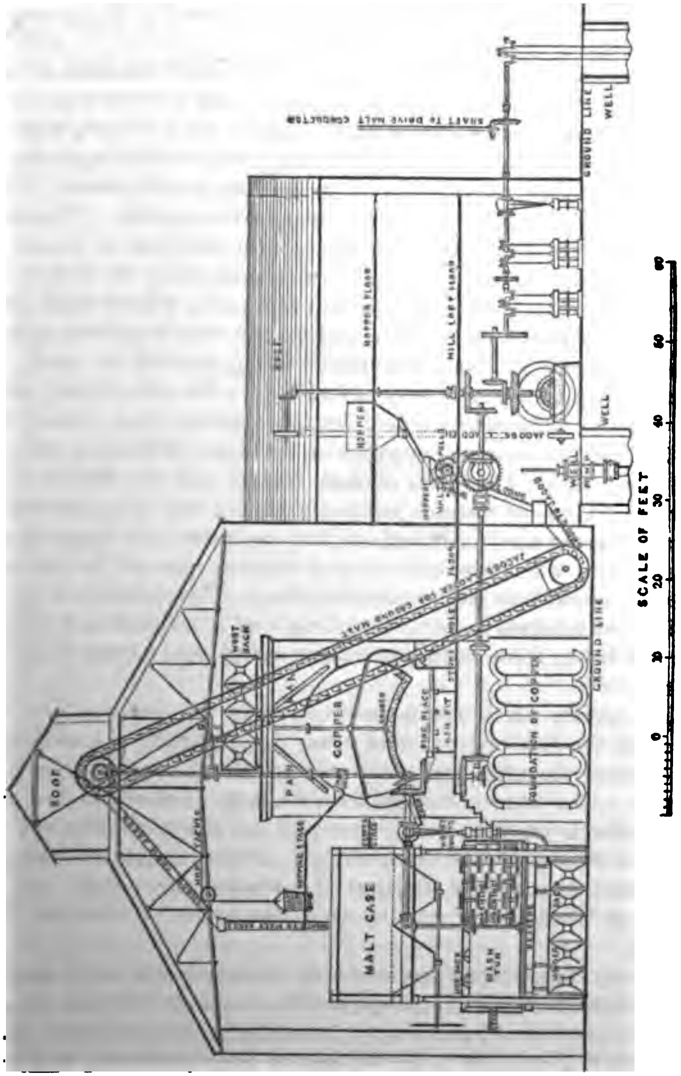


Fig. 5.

crushing apparatus in the building to the right of the great brewhouse. Most of the vessels and apparatus have the names attached, whereby the reader, by occasional reference to the cut, can follow the routine of processes.

To begin at the beginning, let us suppose the furnace-fires to be lighted. The door of each furnace is opposite the western wall of the building; and a passage leads along the sides of the furnaces, with the furnace-doors on the one hand, and large cellars or receptacles for coals on the other, one in front of each of the five furnaces. These cellars are supplied with coals in a very ingenious manner. The coals, when brought to the brewery, are placed in a coal-yard or court, and from thence are conveyed to another receptacle within the brewhouse. Here a box, capable of holding about two sacks, is filled with coals, drawn up by means of tackle, placed upon a very ingenious railway situated between the wall and the furnaces, parallel to both, and wheeled along till it comes over any one of the five coal-cellars, where it is emptied. The coals required for the brewery, about twenty tons per day, are thus conveyed opposite to the doors of all the furnaces with great ease. The form of each furnace, and the details of its arrangement, do not require particular notice; but it is, worthy of remark, that the smoke from all the furnaces enters one large subterraneous flue, which conducts it to a chimney situated in the open court, detached from every other building. This chimney is a fine specimen of brickwork, rising to a height of a hundred and twenty feet, and being, from its bulky area, a conspicuous object from the bridge.

The coppers, which are immediately over the furnaces, are employed in the first place to heat water for extracting the saccharine matter from the malt, and afterwards to boil the malt-extract thus obtained. The water is brought from the large reservoirs in the open court, through pipes, to the 'copper-pan' and also to the copper; and at certain times and in certain quantity is allowed to flow into the copper, where it gradually acquires the temperature proper for the process of 'mashing,' or that by which the extract is obtained from the malt.

All kinds of malt liquor may be shortly characterised as being extracts of malt, boiled with or without hops, and then fermented; so that the main processes are those of extracting, or 'mashing,' boiling, and fermenting. The water in the copper is for the first of these processes; and while it is gradually heating, the malt is being conveyed to the 'mash-tun.' We have before stated, that the crushed malt, or 'grist,' is conveyed, by a long 'Jacob's ladder,' nearly to the top of the brewhouse. Here the buckets deposit their contents into a small vessel, from which five pipes ramify, each pipe leading to one of the 'malt-cases.' The top of each pipe has a kind of sliding door or portcullis drawn across it, by the management of which the grist may be made to descend whichever of the pipes may be desired. The malt-case is merely a receptacle to hold sufficient malt for one mashing, until such time as that process is to be conducted; and when this time arrives, four valves are opened in the bottom of the malt-case, whereby the malt speedily falls into the 'mash-tun.' This last-named vessel is circular, and is provided with a double bottom, the upper one of which is pierced with very small holes: the space between the two bottoms is placed in communication with the copper by means of a pipe, and a few large holes, closed with plugs or taps, occur in the lower or true bottom.

This being the arrangement, and the mash-tun being supplied with malt, a proper quantity of water is allowed to flow from the copper to the space between the two bottoms of the tun; and, percolating upwards through the small holes, it mixes with the malt. The malt and the water are then stirred about by means of a mashing-machine set in rotation by the steam-engine; and after this has continued for a certain length of time, the water, which now contains a large proportion of malt-extract, is allowed to flow from the tun into the square 'under-back,' the taps in the bottom being turned on for this purpose, and the holes in the false bottom being too small to allow any of the malt to pass. The liquor thus produced is called 'wort.'

A pump is next brought into requisition, to pump the wort from the 'under-back' into the copper. Here, for the first time, our attention is directed to the hops. Most persons are aware that it is the flower of the hop-plant which goes by the general name of 'hops,' and that this imparts a peculiar bitter, without which beer would not be recognised as such. The hop-flowers are pressed into large canvas bags, and in that state are conveyed to the brewery, where they are ranged in large warehouses near the brewhouse till wanted. The bags are hauled up into the brewhouse, conveyed to the upper part of the copper, and the hops thrown in at a door in the copper called the 'man-hole' (this being the hole at which the men go in to clean the copper after each brewing). The wort and the hops are then boiled together, until the flavour of the latter is sufficiently imparted to the former, the hops being constantly stirred by a rotating machine called a 'rouser.'

The boiled wort next descends, through a shoot or trunk, from the boiler to a very large square vessel, called a 'hop-back' (almost hidden behind the mash-tun in our section). As the hops as well as the liquid descend through the shoot, the hop-back is provided with a perforated false bottom, through which the wort flows, leaving the hops above the perforation. The capacity of this vessel cannot be less than four thousand cubic feet; and when filled with boiling wort and hops, the clouds of steam rising from the open surface are, as may easily be imagined, most profuse.

The wort is pumped from the hop-back into 'coolers;' but before we follow it in this process, it may be desirable to say a few more words respecting the great brewhouse. Three of the coppers and three of the mash-tuns, with the accompanying vessels, are employed for the brewing of porter, while the others are for ale: one hop-back, too, is for porter, and the other for ale. The fermentable matter obtained from the malt is not all extracted at one time; and, therefore, the 'grist' is covered with hot water two or three times, the extract or infusion each time being called a 'mash.' The hops, in like manner, do not lose all their valuable qualities by once boiling, and are, therefore, used again, in fresh portions of boiling wort. In order to convey the drained hops back again to the copper, a number of men strip off their upper garments, and get into the hop-back, where they shovel the wet hops, still scalding hot, into a tub or bucket, which is drawn up, wheeled along a stage, and emptied into the coppers. This operation has rather an extraordinary appearance, for the men are enveloped in steam, and are moreover liable to severe injury if any of the hot wet hops touch the upper and unclothed parts of their bodies. The hops from the porter-brewing are re-conveyed to the coppers in this way; but those from the ale-brewing are carried up by a 'Jacob's ladder,' which dips at the lower end into the hop-back, and empties the hops into the boiler at the top. When the malt and the hops are thoroughly spent, they are thrown into the street, and thence carted away, the one under the name of 'grains,' to be used as food for cattle and swine, and the other as manure.

Adjoining the western side of the brewhouse are large ranges of buildings, through which the wort passes in the subsequent processes. The first process necessary after draining from the hops is a rapid cooling, which is effected in a manner somewhat striking to a stranger. At the upper part of a lofty building are two spacious cooling-floors, one over another; the sides of the rooms being open for the free access of air. Each floor is of immense extent, perfectly level, and perfectly clean, and exposes a surface of not less than ten thousand square feet. The floor is divided into compartments by raised ledges a few inches in height, and into the compartments thus formed the hot beer or wort is pumped from the hop-back. The surface of the stratum of beer being so very large in proportion to the depth, the air which is wafted over it from the open sides of the room cools the beer in a short space of time. In some particular states of the weather, when the beer is not cooled with sufficient rapidity by these means, it is passed through a refrigerator, in which it is brought into close connection with cold spring water, thus effecting a rapid reduction of temperature.

Our visit next led us into that part of the building where the process of fermentation is carried on. The cold beer or wort is allowed to flow into four enormous square fermenting vessels technically called 'squares;' and in these wooden vessels, one of which will hold fifteen hundred barrels of beer, the liquid is fermented with yeast for a certain space of time. On ascending a ladder to look into one of these squares, a visitor not only remarks the singular appearance of the thick masses of yeast covering the surface of the beer, but soon becomes sensible of the suffocating fumes of the gas emanating from it and hovering in a kind of mist over the surface.

The routine of operations next takes us to a spacious room called the 'tun-room,' in the lower part of a building, of which the middle story is occupied as hop-lofts and the upper as the coolers just alluded to. This tun-room contains nearly three hundred cylindrical vessels, ranged with great regularity in about twenty rows of fifteen in a row, each vessel holding upwards of three hundred gallons. These vessels are called 'rounds,' and pipes and cocks are so arranged at the bottom of each as to allow them to be filled with beer from the fermenting squares, at a certain stage in the process. Between the rows of vessels are long troughs, into which the yeast, worked off by the beer through a hole in the top of each vessel, is conducted along a sloping shoot or channel, a mode of arrangement represented in the next cut. This process of working off the yeast is called 'cleansing,' and is important to the future quality of the beer; and although it is a process somewhat dirty and unpleasant in small or domestic breweries, yet here all is clean, regular, and orderly: indeed this is not the only proof which

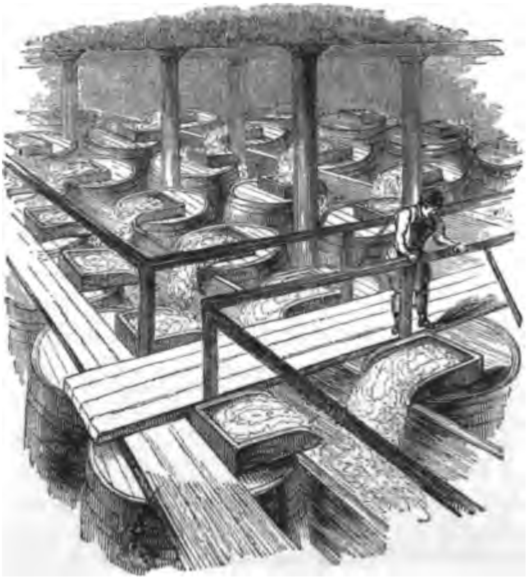


Fig. 6.

such an establishment affords that the large extent of the operations is the very circumstance which leads to cleanly and orderly arrangement, from the absolute necessity of economising room and time.

Sunk in the floor of the tun-room, beneath the 'rounds,' is an oblong tank, lined throughout with white Dutch tiles, and intended for the occasional reception of beer. This tank would float a barge of no mean size, being about a hundred feet in length and twenty in breadth.

On proceeding westward through the brewery from the main entrance, all the buildings which we have yet described are situated at the right hand; but we have now to cross to the southern range, separated from the other by an avenue, over which a large pipe crosses to convey the beer from the 'rounds' to the store-vats. These vats are contained in a series of store-rooms, apparently almost interminable: indeed all that we have hitherto said as to vastness is much exceeded by the array which here meets the eye. On entering the store-buildings, we were struck with the silence which reigned throughout, so different from the bustle of the manufacturing departments. Ranges of buildings, branching out north, south, east, and west, are crammed as full of vats as the circular form of the vessels will permit; some larger than others, but all of such dimensions as to baffle one's common notions of 'great' and 'small.' Sometimes, walking on the earthen floor, we pass immediately under the ranges of vats (for none of them rest on the ground), and may then be said to have a stratum of beer wenty or thirty feet in thickness over our heads: at another, we walk on a platform level with the bottom of the vats; or, by ascending steep ladders, we mount to the top, and obtain a kind of bird's-eye view of these mighty monsters. Without a guide, it would be impossible to tell which way we are trending, through the labyrinth of buildings and lofts, surrounded on all sides by vats. At one small window we catch a glimpse of a churchyard, close under the wall of the storehouse; and, on further examination, we find that the buildings belonging to the brewery, principally the store-rooms, have gradually but completely enclosed a small antique-looking churchyard, or rather burial-ground (for it does not belong to any parochial church). In this spot many of the old hands belonging to the establishment have found their last resting-place, literally surrounded by the buildings in which they were employed when living.

The space occupied as store-rooms may in some measure be judged, when we state that there are one hundred and fifty vats, the average capacity of each of which, large and small together, is upwards of thirty thousand gallons. The town of Heidelberg, in Germany, has gained a sort of celebrity for possessing a tun of vast dimensions, capable of holding seven hundred hogsheads of wine; but there are several vats among those here mentioned, in each of which the Heidelberg tun would have "ample room [and verge enough" to swim about. Fig. 7 is a sketch of one of the largest vats, which contains about three thousand barrels, of thirty-six gallons each, and weighs, when full of porter, about five hundred tons!

Leaving this array of vats—these silent giants of the brewery—we next visited the ale department, of which little has yet been said. The distinction between ale and beer is well known by the taste, but is not easily described in words: ale is of greater specific gravity, lighter coloured, more transparent, and less bitter than porter. Whether or not we assent to the dictum of Autolycus, in the 'Winter's Tale,' that a "quart of ale is a dish for a king," it is certain that a malt liquor

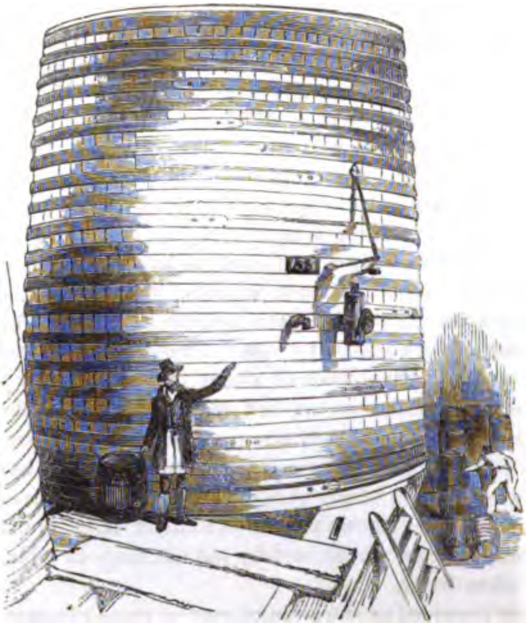


Fig. 7.

more or less resembling the ale of modern times was much in vogue among our forefathers centuries ago.

It was mentioned in a former paragraph, that two out of the five sets of brewing vessels are employed for the brewing of ale. These two are at the northern end of the brewhouse, and are used nearly in the same way as the porter vessels. The water is conveyed from the cistern to the copper, and there heated; the crushed malt is introduced, first into the malt-case, and then into the mash-tun; hot water is allowed to flow to this malt from the boiler; the mashing process follows, and the wort, when drained off from the malt into the under-back, is pumped into the boiler; the hops are introduced and boiled with the wort; and, lastly, the whole contents of the copper flow into the hop-back, where the wort is strained from the hops. All this nearly resembles the process followed in porter-brewing; but the hot ale-wort travels by a very different route. We have alluded to an elegant iron suspension-bridge, which passes over a street from the great brewhouse to a building termed the "Ale-brewery." Along the bottom or floor of this bridge are laid three pipes, one to convey gas for lighting the ale-brewery, another for cold water from the cisterns, and a third for conveying the hot ale from the hop-back to the coolers in the ale department. This latter structure, nearly fire-proof, is built with much elegance, and consists of the necessary rooms for the completion of the ale-brewing. The hot ale-wort, passing from the hop-back over the suspension-bridge, is conveyed to the top of the ale-brewery, where it is spread out on two cooling-floors, separated, like those in the porter-brewery, into compartments by means of raised ledges, and, like them also, exposed to the free access of air on all sides. The cooling being effected by exposure on these floors, and afterwards by passing through a refrigerator, the ale-wort descends to the story containing the fermenting vessels, which is on a level with the suspension-bridge; and here, in various vessels, some square and others round, the wort ferments, and assumes the state of ale. Again descending, the ale enters the 'tun-room,' to undergo the process of cleansing. About three hundred and fifty cylindrical casks, or 'rounds,' each containing about a hundred and fifty gallons, are ranged in great order throughout this large room; and here the ale remains till in a fit state to be vatted. Once again descending, we arrive at the level of the street, where, passing through a dark spacious store-room, we see immediately overhead an uninterrupted range of vats, into which the ale flows from the 'rounds.'

The water conveyed over the suspension-bridge is deposited in a cistern at the top of the ale-brewery, and from thence flows to the various stories as required. Adjoining the southern end of this building are large ranges of storehouses occupied by ale-vats.

We now again cross to the principal range of buildings, and offer a few remarks descriptive of the mode of filling the butts with beer. The butts in which the beer is conveyed to the publicans, and which are so well known in the streets of London, contain one hundred and eight gallons each. A hose, similar in form to those which are attached to fire-engines, is connected at one end to a hole in one of the vats, and at the other to the bung-hole of the butt, the latter being placed on the ground with that hole uppermost. Then, by means of a tap or valve governed by a handle, the beer is made to flow from the vat, through the hose, to the butt or barrel; and when one butt is in this way filled, the end of the hose is quickly transferred to the hole of a second butt, which is filled in a similar manner.

Fig. 8 represents a man engaged in this process of 'drawing off,' which is effected in cellars on the level of the ground, of which there are several. Some of the store-vats are ranged round these cellars; while those which are at a greater distance are placed in connection with the cellars by pipes and hose.

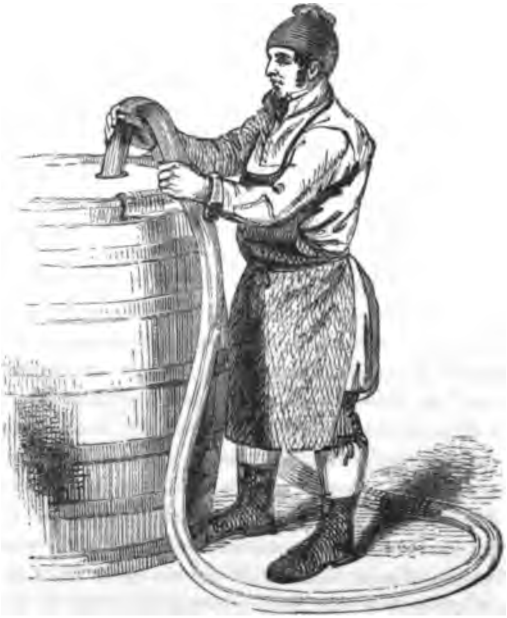


Fig. 8.

Most persons perhaps are aware that malt liquors, after fermentation, require a process called 'fining,' to render them more clear and transparent. The liquid with which this is effected is made at the brewery; and on visiting the building where the manufacture takes place, we found that, small as is the quantity required for each butt of beer, the process is conducted on a considerable scale. The building is at the left hand of the principal entrance to the brewery, and consists of three or four stories or tiers, each filled with square vessels, in which the fining liquid (a solution of isinglass and other analogous substances) is prepared. A very small quantity of this liquid is used to every butt of beer.

Westward of the main body of the brewery buildings is a large paved yard; looking across which towards the north-west, we espied such an array of butts, puncheons, and barrels as excited no small surprise. These were not filled with beer or ale, but had been brought empty from the cellars of the publicans, to be repaired and cleansed before again using. One of the undeviating rules in these establishments,—the golden rule, indeed,—is to observe the greatest cleanliness in every part of the processes; nearly every vessel, large and small, however frequently it may be emptied and filled, and in whatever part of the operations it may be employed, is cleansed after each time of using: according to the nature or condition of the liquid contained in the vessel, so is there a particular mode of cleansing adopted. The butts in which the beer is conveyed from the establishment are especially attended to in this respect. A chimney at the west end of the yard points out the spot where the cleansing or steaming house is situated, and in which the process is conducted in an ingenious manner. The butts or barrels to be cleansed are ranged, a certain number at a time, round the sides of the building, immediately over a horizontal pipe containing steam from an adjacent boiler; and from this pipe a number of jets or short pipes branch upwards, and pass into the bung-holes of the casks, one to each cask.

But these casks are not only cleansed after every time of using, they are also inspected and measured; and if any leakages or injuries appear, the means of repair are at hand. Adjoining the building where the cleansing is effected, a very large cooperage is seen, occupying three sides of a square court. Here we trod our way with some difficulty among casks, old and new,—iron hoops that had seen hard service, and others destined to replace them,—staves of various shapes and sizes,—and all the tools and working apparatus necessary for a cooperage on a large scale.

Under a range of sheds forming part of the circuit of the large open court are the casks which have either been repaired and cleansed, or are waiting for those operations. There they lie, side by side, one on another, one behind another, in a solid mass of extraordinary extent. Some idea of the number of casks lying here ready to be filled may be formed from the fact that the whole number of butts, puncheons, barrels, and similar vessels belonging to the establishment is between sixty and seventy thousand!

It has not formed part of our object to detail the number of hours employed in each part of the brewing processes, nor the particular time of day at which they commence; but the reader will probably suppose that the operations are continued by night as well as by day. The coppers are almost uninterruptedly in use, and relays of workmen succeed each other to attend them. But not only within the brewhouse is activity displayed betimes in the morning; in the open court, long before sleepy London has roused its head, the draymen are busy in hauling up the butts of beer, and placing them on the drays. So many butts are sent out from the establishment every day, and the advantage of conveying them in drays through the metropolis at as early an hour as possible is so great, that by four o'clock in the morning all is bustle and activity—clerks and foremen superintending the operations, and men working the cranes by which the butts are lifted from the cellars to the drays. The form of these drays, of which seventy or eighty are constantly at work, is familiar enough to every Londoner; and we doubt not that the *ears* of many passers-by would be grateful for the addition of springs or some other appendage to the drays, whereby their rattling, shaking, deafening progress over the paved streets might be in some degree subdued: we believe that something of the kind has been already adopted.

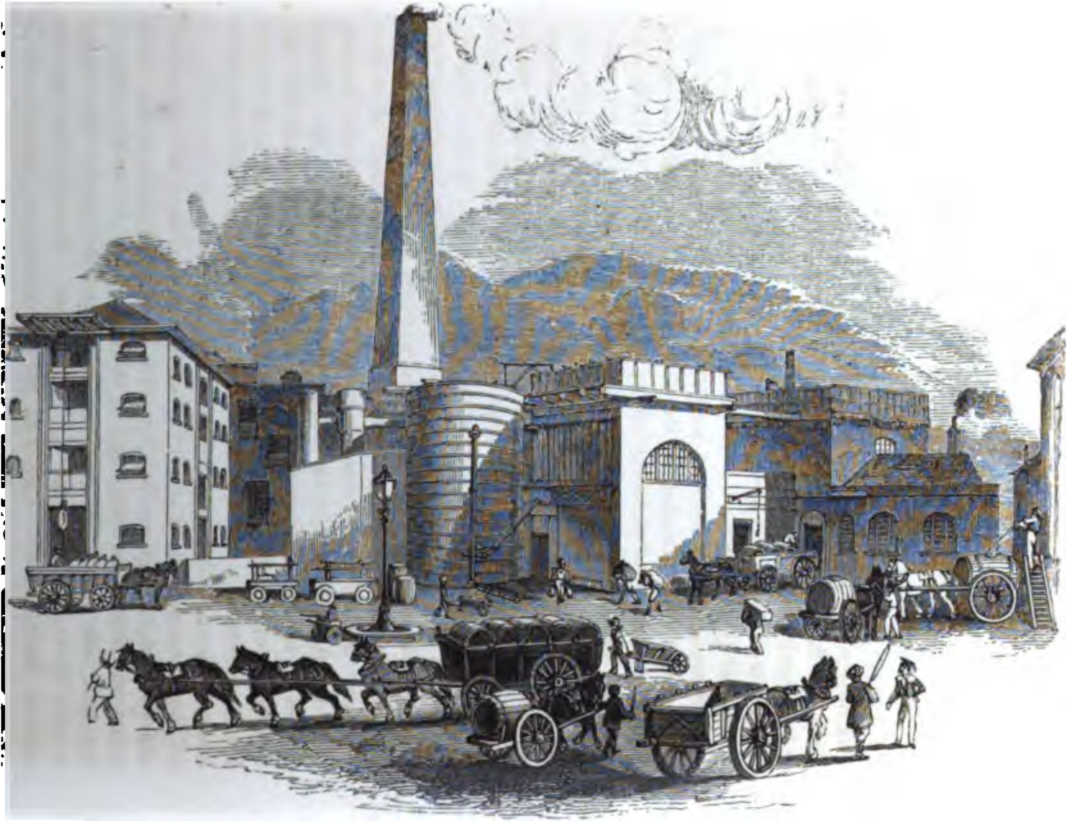
If the brewers' drays are well known in London, what shall we say of brewers' horses? Who ever mistakes a brewer's horse for any other? who, that has ever passed one day in the London streets, has failed to remark these noble but unwieldy creatures,—unwieldy from very strength? And the draymen too: here are specimens of the "physical man!" The horses seem made for the men and the men for the horses; and we can hardly fancy such horses driven, or ridden lady-wise, except by such men. In the course of our visit, we passed round the extensive stables where the horses belonging to the brewery, nearly two hundred in number, are kept. Here were marks of the same well-organized system, the same cleanliness and order, as so many other parts of the establishment present. Southward of the little burial-ground and of the store-buildings is a very large paved court, around which are the stables and subsidiary offices: here, a dwelling-house and laboratory for the veterinary surgeon, under whose care the health of the valuable stud is placed: there, a blacksmith's shop, provided with the necessary arrangements for shoeing horses: farther on, a harness-maker's shop, where necessary repairs to the harness are effected. But the principal of these buildings are, as may be supposed, the stables, one range of which extends nearly three hundred feet in length. A clear passage leads throughout from end to end, the horses being ranged on either side with great regularity; galleries or lofts for provender above them; and an open space for ventilation along the middle of the stables. At one end of the long stable is a building in which the provender is prepared for the horses: a small steam-engine, of five or six horse power, works machinery by which the oats are bruised or crushed before being given to the horses (a modern practice, productive of much benefit to the health of the animal); and another machine by which the chaff is cut. By an ingenious arrangement, the waste steam from this engine can be directed into a water-trough, whereby any desired temperature may be given to the water which the horses drink.

In our ramble through the brewery, we came to a building where "Barclay, Perkins, and Co.'s Entire" stared us in the face in all shapes, colours, and sizes; some boards higher than they were wide, others wider than high; some flat, some convex; some with gold letters on a green ground, others on red. These were the inscription-boards, so well known in the London streets, and so puzzling to strangers, who cannot conceive what the "Co.'s Entire" means. It appears that in bygone times, beer-retailers were wont to sell a kind of liquor called half and half, that is, half ale and half 'twopenny,' which had to be drawn from two casks. Afterwards a taste was gradually acquired for 'three-threads,' a compound of ale, beer, and twopenny, which the retailer was necessitated to draw from three casks,—a process so troublesome, that it led to the brewing of a kind of beer which should combine the qualities of these three sorts, and which, being drawn entirely from one cask, obtained the name of *entire* butt beer. The circumstances under which the necessity arose have long since passed away; but the term is still retained. The inscription boards, which inform us whose "Entire" is sold by the publican, are made in the part of the establishment to which we alluded above. One shop is devoted to the carpenters who prepare the boards, and another to the painters and gilders who finish them.

Before concluding our necessarily hasty sketch of this vast establishment, we may observe that it is something more than a brewery: it is a memorial of past times, carrying us back to the period when the Globe theatre occupied part of the site; and later, when Dr. Johnson was domiciled in an apartment over the entrance gate. In Boswell's

'Life of Johnson' there are numerous letters and reports of conversations relating more or less to the brewery; but without entering upon these, we may briefly state how the great lexicographer became connected with this spot.

It appears that in the early part of the last century the brewery belonged to a Mr. Halsey, who reaped a fortune there, and upon the marriage of whose daughter to Lord Cobham the brewery was sold to the elder Mr. Thrale. Thrale was an active and liberal man; became sheriff of the county, and M.P. for the borough; and died in 1758, leaving his property to a son whom he had educated liberally. This son married a Welsh lady of good family, and, to use the words of Boswell, "although in affluent circumstances, he had good sense enough to carry on his father's trade, which was of such extent, that I remember he once told me he would not quit it for an annuity of ten thousand a year; 'Not,' said he, 'that I get ten thousand a year by it, but it is an estate to my family.'" The beer brewed by Thrale at the period here alluded to was about thirty thousand barrels annually, not one-twelfth part of the quantity now brewed in the same establishment, which produces as much as the nine principal breweries did in 1760. In 1765 Dr. Johnson was introduced to Mr. and Mrs. Thrale by Malone; and from that time till the brewer's death, Johnson lived almost entirely in their houses, at the brewery and at Streatham. Before the fire at the brewery in 1832, the room was pointed out, near the gate, in which the Doctor wrote many of his most celebrated productions, more particularly his Dictionary. In 1781 Mr. Thrale died, and as he had no sons, the executors, of whom Dr. Johnson was one, deemed it desirable to dispose of the brewery. It was sold jointly to Mr. Barclay and Mr. Perkins (the latter of whom had been the superintendent of the brewery) for the enormous sum of one hundred and thirty-five thousand pounds! Boswell relates: "When the sale of Thrale's brewery was going on, Johnson appeared bustling about, with an ink-horn and pen in his button-hole, like an exciseman; and on being asked what he really considered to be the value of the property which was to be disposed of, said, 'We are not here to sell a parcel of boilers and vats, but the potentiality of growing rich beyond the dream of avarice."



[illegible] Messrs. Smith and Co.'s Distillery, Thames Bank.—Face p. 41

III.—A DAY AT A DISTILLERY.

The object of the next visit takes us up the river to the vicinity of Chelsea. Let us, then, get on board one of the little river-steamers, and proceed in that direction.

After passing under Vauxhall Bridge, we stop for a few moments—as everybody now knows—at the Nine-Elms pier, and thence proceed onward towards the termination of the route at Chelsea. On the left we pass the South London Water-works, as well as factories, warehouses, and wharfs of different kinds; and then arrive at the river-side house so well known to all amateur boatmen as the 'Red House.' On the right, after passing a gas-factory, we see the noble manufacturing premises of Messrs. Cubitt, the builders, with the chimney inclosed in a decorated square tower. Then we come to the London Steel-works; beyond which is the Belgrave Dock; and westward of both are two tall chimneys, one of which points out the Chelsea Water works, and the other the distillery of Messrs. Octavius Smith and Co., the establishment to which our attention is here directed. This latter-named chimney is conspicuous from the river on account of its proportions, the celebrated obelisk called 'Cleopatra's Needle' having been taken as a model in its construction; and although the summit has been somewhat shorn of its beauty by a lightning-stroke, the symmetry of its form is still observable. The river-front of this factory presents to view a dock, whereinto barges laden with corn and coals for the factory are conveyed to be unladen.

The entrance to the distillery is on the eastern side; and on entering the outer gates we find ourselves in an irregularly-shaped open court, surrounded by buildings, of which several are seen on Fig. 1. On the left are large granaries, in which the grain, after being hoisted from barges in the dock, is stored. Beyond these we see various buildings connected with the still-room, comprising a cylindrical worm-tub of very large dimensions, water-tanks and cooling-tanks at a considerable elevation, store-warehouses, &c. In front are the offices and counting-houses; bounded on the right by various workshops for smiths, millwrights, coppersmiths, carpenters, and others engaged in the repair and adjustment of the apparatus used in the distillery. On the right of the entrance, and extending to a considerable distance northward, are the mill and the brewhouse, wherein all those operations are conducted which precede the actual distillation. Stables and other outhouses occupy other parts of the area; while the open court presents a busy scene of traffic: here waggons being laden with casks about to leave the distillery; at another spot yeast being brought in from the great London breweries; at a third, 'grains' being carted for conveyance to the dairies; and at a fourth, men filling barrels with 'spent-wash,' to be carried away as a fattening ingredient for cattle and pigs.

Before describing the operations of this establishment, it may be well to explain briefly the meaning generally attached to the terms 'distillation' and 'distillery.' All kinds of grain, such as wheat, rye, barley, oats, &c., whether in the raw or the malted state, as well as the juices of fruits, of the sugar-cane, of potatoes, of beet-root, and of many other vegetable substances, contain certain elements which, by peculiar processes, are capable of being converted into *alcohol* or *spirit*. Distillation always forms one of these operations; but it is preceded by others which vary according to the nature of the ingredients employed. The various liquids known by the names of brandy, rum, whiskey, hollands, gin, spirits of wine, cordials, and compounds, all contain the alcoholic principle, developed to a greater or less extent by the process of distillation. French brandy is produced from wine; West Indian rum from sugar or molasses; and British spirit, whether called by the name of spirit of wine, British brandy, British rum, whiskey, or gin, from corn. In every case the substance which undergoes the process of distillation is a *sweet* liquid; but the means whereby this sweetness or saccharine quality is brought about differ according to circumstances. The different qualities presented by these various liquids depend partly on the alcoholic strength, partly on the substances whence they are produced, partly on the berries, herbs, and seeds with which they are flavoured, and partly on the mode in which the manufacture is conducted.

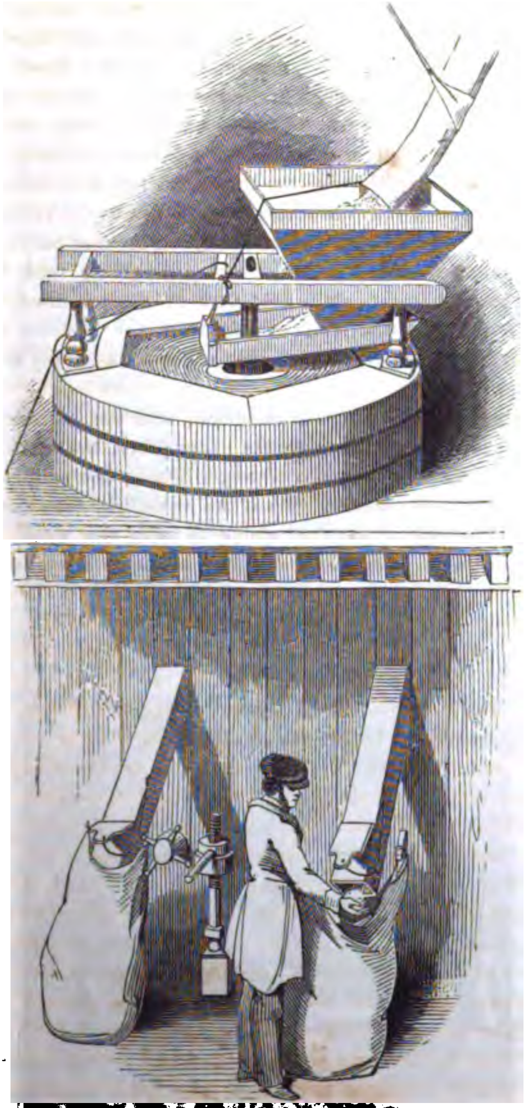
We are thus prepared to understand that the operations of a British distillery relate to the extraction of the alcoholic principle from various kinds of grain. We must next bear in mind that the extract produced from this grain is *brewed* before being distilled: it is in fact converted into a kind of beer before that change is induced which leads to the production of spirit. Hence it follows that many of the operations of a distillery resemble those of a brewery. The brewer and the distiller alike extract a saccharine substance from grain (principally *malted* in respect to brewing, but more generally *raw* for distilling), by the process of 'mashing;' and alike subject this sweet liquid, called 'worts,' to fermentation. The fermented liquor, modified in a particular way, forms 'beer' at the brewery; whereas in a distillery it obtains the name of 'wash,' and is the liquid which undergoes the subsequent process of distillation.

The staple ingredient, then, at the distillery, is grain; and this, in reference to the establishment to which our attention will be now directed, is brought in barges belonging to the firm. These barges are laden from the vessels which bring the grain from various ports, the grain being brought in sacks containing four bushels each. The dock is so contrived that the barges can float in at high-water, and pass immediately under the granary, into which the sacks are hoisted from the barge by means of tackle of the usual kind. The granary is a large brick building, having three extensive floors, on which the grain is stored. This grain consists of both the malted and the raw kinds, the relative qualities of which may be thus briefly noted:—that malt is barley which has undergone, on the premises of the maltster, a process calculated to render it more fitted for the purposes of the brewer than barley or other grain in the raw or unmalted state; but that the distiller can employ either raw or malted grain according to circumstances. Malt being much more expensive, on account of the duty, than raw grain, the distiller usually employs as little of the former as the nature of the process requires. The proportion is now frequently one part of malt to ten or twelve of raw grain; the raw grain being varying mixtures of wheat, barley, rye, and oats, according to the state of the market; but more than half of the entire ingredients is generally raw barley.

On one of the granary floors might be seen a heap of about two thousand quarters of kiln-dried barley, lying in a stratum five feet thick, and waiting to be conveyed to the mill. All the grain required at the distillery, about forty thousand quarters per annum, passes thus through the granary; and when about to be ground into meal, it is conveyed to a room immediately over the mill-room, and discharged through trap-doors in the floor into cloth pipes, which conduct it to the millstones. To the mill-room we next descend; where we see six pairs of mill-stones, ranged in a circle, and set in motion by a shaft from the steam-engine rising up in the centre of the group. These six pairs of stones, kept wholly or partially at work according to circumstances, grind all the raw grain; while the malt is passed through a 'crushing-mill,' consisting mainly of two rollers placed nearly in contact. The object of this difference is, that the distiller requires to *crush* the malt, instead of *grinding* it—the internal substance being by this means softened or disintegrated without cutting the husk, a precaution which is not found necessary in the case of raw grain.

A visitor must expect to leave this mill-room as white as a miller; nor is he less plentifully sprinkled with meal when he descends to the room beneath. This lower room contains a vertical cylindrical partition, having within it the mechanism whereby the mill-stones are rotated in the room above, and around it pipes or openings, through which the ground meal descends from the mills. The mill-men fasten sacks to these openings, and thus receive the meal as it descends, heated to a temperature of perhaps 100° by the friction of the stones. Fig. 2 represents the general nature of the operations in both these floors of the mill; the upper division showing the position of the millstones in the room above, and the lower showing the reception of the ground meal in the room beneath.

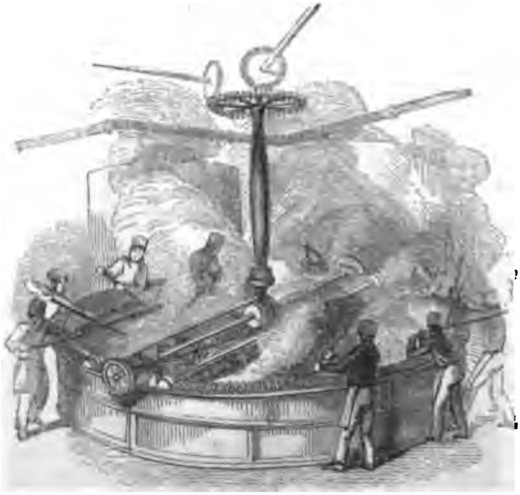
We next trace the meal, thus ground, to the brewhouse, through a gallery or covered way, leading from the south to the north department of the establishment. In this brewhouse are three large coppers, each provided with a fireplace underneath, and the whole capable of containing about fifty thousand gallons; these are for the purpose of heating the water wherewith the brewing process is effected. The most important vessels in the brewhouse are the 'mash-tuns,' two in number: these are cast-iron circular vessels, upwards of twenty feet in diameter, and each capable of containing twenty thousand gallons; each is provided with a double bottom, one above the other, having a small vacancy between them, and the upper one being pierced with small holes an inch or two apart. From the middle of each tun rises a vertical shaft, set in motion by a steam-engine, and acting upon horizontal arms, studded with spikes or pins on all sides: this apparatus, by rotating both horizontally and vertically, effectually stirs and agitates any ingredients which may be in the tun.



Grain-mill and Meal-sacks.—Fig. 2.

All being ready for the brewing, hot water is admitted to the 'mash-tuns' by pipes leading from the coppers; while ground meal is thrown in at the open top of each tun. The sacks of ground meal are stored in the mill adjoining the brewhouse, and are from thence wheeled to the tun on low hand-carriages. This is a very bustling scene when a 'mashing' is about to commence, ten or a dozen men being employed to wheel in the sacks, discharge the meal, and return for another cargo. We may here remark that the water is conveyed to the coppers from a very large cast-iron tank, or 'liquor-back,' on another part of the premises: it is pumped into this tank from a reservoir sunk below the level of the ground in the north-west part of the premises, the reservoir being supplied by a pipe leading from the Thames at a point within the limits of low-water; so that a constant supply of water is thus obtained.

The crushed malt, the ground grain, and the hot water, being admitted into the tuns in the requisite proportions, the rotating stirrer or 'mashing-machine' is put into action, whereby the solid and liquid ingredients are so completely mixed up together, that the water is enabled to extract the saccharine elements from the meal. Men are also employed with long-handled instruments to stir the sediment,

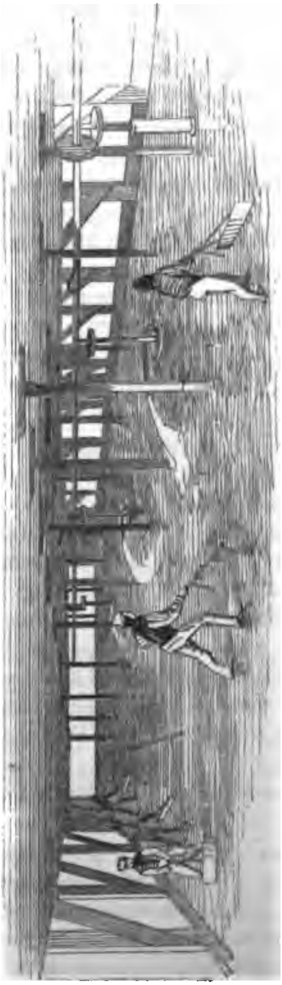


Mash-tun.—Fig 3.

which might otherwise remain at the bottom; and a scene is then presented such as is shown in Fig. 3. These operations continue for two or three hours, during which a striking chemical change has been going on. Meal consists principally of *gluten* and *starch;* and by the agency of water and a sufficient temperature this starch becomes converted into sugar. The precise explanation of this change involves chemical niceties into which we need not enter; but it will be sufficient to say, that the water, converted into 'worts' by the process of mashing, acquires a sweet though sickly taste, arising from the starch of the meal having been converted into sugar.

When the 'mashing' has been continued to a certain extent, five or six pipes are opened, through which the 'worts' are allowed to flow into cast-iron cisterns called 'under-backs,' in a cellar beneath. The meal is retained by the upper or false bottom of the mash-tun, which thus acts as a sieve or strainer, allowing nothing but liquid to pass through the perforations. The meal does not lose all its saccharine quality by this first mashing: it is therefore 'mashed' a second and a third time, in fresh portions of water; producing 'worts' of less and less strength. As to the number of times that the mashing is repeated, the quantity of water used for a given weight of meal at each mashing, the temperature of the water, and the length of time during which the mashing is continued—these are points on which each individual manufacturer exercises his skill and judgment, and may possibly vary considerably in different establishments. When the saccharine qualities of the meal are as far as possible extracted, the residue, under the name of 'grains,' is carried out to the grain-stage, in the yard of the distillery, thence to be sold as food for cattle.

From the under-backs, the 'worts' are pumped up to the coolers or cooling-floors, occupying the upper portion of a building contiguous to the brewhouse on the north. These floors are covered or paved with cast-iron plates, three or four feet square, and joined edge to edge; raised ledges are placed across the floors at certain distances, to divide them into compartments; and into the shallow cells or trays thus formed the hot wort is introduced. The whole floor, upwards of a hundred and fifty feet in length, becomes thus covered with a stratum of hot liquor five or six inches deep, which is speedily cooled by the access of air from open windows on all sides of the coolers. This speedy cooling is necessary to prevent the acidification of the sweet wort, a result which has a tendency to follow when the cooling is too



Cooling-floors.—Fig. 4.

slowly effected. There are two of these cooling-floors, both paved with cast-iron plates, and both arranged in a similar manner. Such a mode of cooling is very prevalently adopted in the large breweries and distilleries; though in some cases 'refrigerators' are employed, in which the hot wort passes through pipes exposed externally to a current of cold water. It is merely a question of expediency as to which method is employed; for the principle is the same in both cases, viz., the rapid abstraction of heat by a medium colder than the wort itself. In Fig. 4 is represented one of these floors, covered with the hot liquid, and supplied with certain pieces of apparatus whereby a current of cool air is more effectually kept up.

From the coolers the wort descends into the 'fermenting-backs,' a series of square vessels of enormous dimensions: they are sixteen in number, each about thirty feet long and half as wide, having an aggregate capacity of nearly half a million gallons. Here the liquid is exposed to the action of *yeast*, bought for that purpose of the great porter-brewers: the alcoholic fermentation ensues, whereby the sugar, which had been developed from the grain during the process of mashing, becomes converted into alcohol or spirit. This is one of the most delicate of all the operations, whether in a brewery or a distillery, requiring extensive knowledge both of the principles of chemistry and of practical results. The nature of the process may be briefly explained as follows:—The wort, in consequence of containing a considerable amount of saccharine matter in solution, is heavier than water; and the manufacturers express the degree of density by stating how many pounds heavier a barrel of wort is than a barrel of water. Whatever may be the strength of the wort actually obtained in any one mashing, the distiller is confined to certain limits when he transfers the mingled wort to the fermenting-tun; for he is obliged by law to bring the wort to a specific gravity somewhere between 1·050 and 1·090, water being 1·000. This specific gravity becomes gradually lessened in the fermenting-backs, by the gradual conversion of the sugar into alcohol; this latter named liquid being very much lighter than water. The specific gravity is in fact brought down very near to that of distilled water, and the wort, now denominated 'wash,' may be considered as a mixture of alcohol and water, containing a small quantity of an essential oil, a little saccharine matter, and one or two other substances.

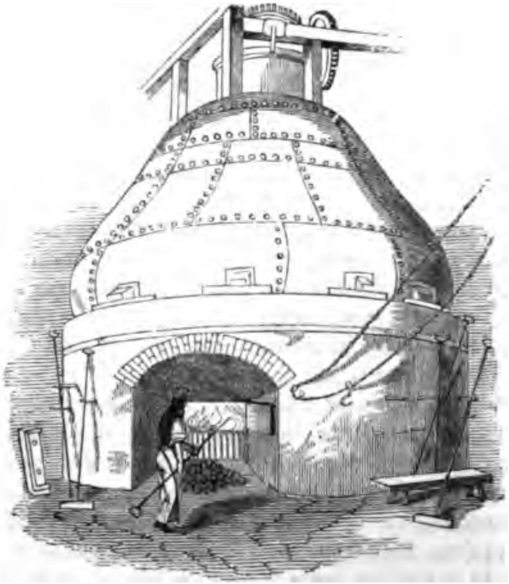
We now come to that part of the distiller's operations where it is desirable to speak of the relations between the manufacturer and the Excise. The system of supervision whereby the revenue in spirits is collected is a remarkable instance of Excise machinery,—a supervision rendered important by the large revenue annually collected, and by the comparatively small number of establishments from which the payments are made. The single firm whose establishment forms the subject of our present notice is said to pay no less a sum than 300,000*l.* a-year to government in duty on the spirits manufactured; and as the duty per gallon is estimated on spirits of one particular degree of strength, the utmost caution is necessary in testing all the spirits produced, as a guarantee that every sample shall pay a duty exactly proportionate both to its quantity and its strength. As agents on the part of the government, there are excise-officers almost constantly present at every distillery, day and night. They succeed each other, one or more at a time as may be necessary, after intervals of eight hours; the periods being from six in the morning till two in the afternoon, from thence to ten at night, and from thence to six the next morning.

The act of parliament by which distilleries are now regulated was passed in 1825. By its provisions no distiller is allowed to commence operations till he has procured a licence, which licence is to be renewed annually; nor is he allowed to keep on his premises a still below a certain capacity. The number of stills, chargers, receivers, &c. employed by him is also placed under certain restrictions; and the precise routine is marked out as to the mode in which the liquid shall pass from one vessel to another in the process of distillation. The number of openings in the principal vessels is expressly stated; and the most scrupulous care is taken that nothing shall pass from one vessel to another without flowing through a pipe provided with a cock or valve of which the excise-officer has the key. He is provided with keys whereby he can lock up the furnace-doors, lock up the stills, and in fact exercise a most thorough control over all the operations. In order further to facilitate the supervision of the excise-officers, the brewing and the distilling take place in alternate periods; one portion of time being appropriated to the preparation of 'wash,' or 'fermented wort,' in the brewery, and the next to distillation of spirit from the wash thus produced. On paying a visit to a distillery, therefore, we are likely to find one-half of the operations suspended, according as it may happen to be brewing-time or distilling-time. These complex arrangements arise principally out of the peculiar mode in which the duty is estimated, for not only is the spirit tested as to quantity and strength during and after the process of distillation, but the specific gravity of the 'wort' and of the 'wash' is taken, the one heavy and the other light, and an assumption is made that a given quantity of spirit will result from a given difference in these two specific gravities. If it happens that the actual quantity of spirit, ascertained after the distillation, differs from the hypothetical quantity arising from the previous calculations of the officer, he gives to the government the 'benefit of the doubt,' and charges duty on the higher quantity, whichever that may happen to be. The mode in which this double system of computation is likely to check improvements in manufacture forms a delicate subject, into which we cannot here enter.

We shall now be prepared to follow a routine of processes in which the excise-officer is an important personage. We have explained that the 'wort,' or sweet liquor arising from the mashing, ferments in the fermenting-backs until its specific gravity is greatly reduced, and its saccharine quality exchanged for one more alcoholic. This liquid, now called 'wash,' is conveyed to a vessel called the 'wash-charger,' as the first step in the distilling process. In order that the intentions of the law may be carried out, which prohibit the simultaneous brewing and distilling in one establishment, the buildings are detached, or at least conveniently divided. The still-house, to which attention may next be directed, is a large, irregular building occupied by the vessels immediately connected with the distillation; the principal of these vessels being called 'chargers,' 'stills,' and 'receivers;' the first to supply the second, and the third to receive the product. A glance through this building enables a visitor to observe that the pipes, of which a large quantity is visible, are painted of different colours. This illustrates another of the peculiar rules whereby the operations of a distillery are governed; for, in order to facilitate the supervision of the officer, and to enable him to trace the routine of processes conveniently, the legislature requires that every pipe for the conveyance of water shall be painted *black*, those for the conveyance of 'wort' or 'wash' *red*, those for the product of the first distillation *blue*, and those for the finished spirit *white*. Another regulation is, that whatever may be the size and arrangement of the distillery, ladders and all other conveniences shall be provided for the easy access of the officer to all the different vessels.

The 'wash-charger,' into which the wash is conveyed from the fermenting-vessels, is a large iron tank or closed cistern, capable of containing about thirty thousand gallons. By the express terms of the law, this vessel must be entirely closed in, and must communicate only with the fermenting-vessel and with the still, so that nothing can flow into it except from the former, and nothing flow out of it except into the latter. In the top or cover is a small hole, about an inch square, into which the officer dips a graduated rod; the object being to determine whether the quantity entering this vessel is the same as had been contained in the fermenting-backs. The officer keeps the key of the cocks or valves leading into and from this vessel, whereby nothing can enter the still until he has unlocked the requisite pipes. Fig. 5 represents one of the two large wash-stills into which the wash flows from the wash-charger. This is a copper vessel capable of containing more than twenty thousand gallons. It is heated by a fire beneath, and is terminated at the top by a cover, which gradually decreases in diameter, and at length joins the 'worm,' of which we shall presently speak. The still is formed of plates of copper firmly riveted, and otherwise so contrived as to be air and water tight.

It will be well here to consider briefly the nature of the process carried on in the large still. The 'wash' conveyed into it consists mainly of alcohol and water, in the proportion (generally) of about six gallons of pure alcohol, or twelve gallons of 'proof spirit,' in a hundred gallons of wash; 'proof spirit' being composed of about equal parts of alcohol and water. Water passes off in the form of



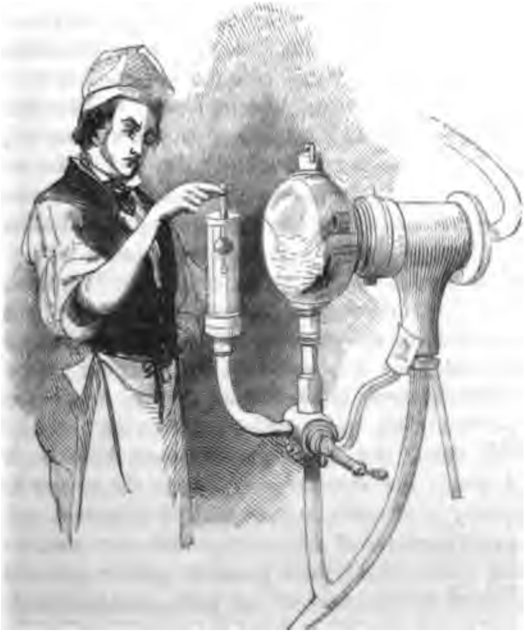
Wash-still.—Fig. 5.

vapour at a temperature of 212°; while alcohol does the same at the low temperature of about 180°; and the distiller avails himself of this circumstance to effect a separation of the two liquids. He applies fire to the still, by which the 'wash' is gradually heated; and when the temperature attains 180°, the alcohol begins to vaporise and to ascend to the top of the still. The heat is kept up to some point between the two extremes of 180° and 212°, until all the alcohol has passed off in the state of vapour. But during this process, partly on account of the restrictions imposed by the legislature, and partly through the scientific difficulties of the subject, a considerable quantity of water passes off with the spirit and mingles with it in the form of vapour. In France, where the operations of a distillery are not so rigidly controlled by the government as in England, improvements in great number have been from time to time introduced, with a view of effecting a complete separation of the two liquids in one operation: to what extent and under what limitations these attempts have succeeded, we need not discuss here; it will suffice to state that in England so much aqueous vapour passes over with the alcohol as to render the latter comparatively weak. When all the alcoholic ingredient is distilled from the wash, the latter, under the name of 'spent wash,' is conveyed from the still to a large open vessel in the yard of the distillery. It is thence carried away in barrels by persons who keep cattle or pigs: the dry food of these animals, being sprinkled with some of the spent wash, acquires a fattening quality, which gives a value to the liquid after it has ceased to possess any to the distiller. Many distilleries have enormous 'piggeries' attached to them, the grunting inhabitants of which are fattened on these dainties.

But it may now be asked, what becomes of the alcoholic vapour driven off by the heat of the still? The answer to this question forms the next step in our routine of processes. In the frontispiece is seen a very large cylindrical vessel near the chimney. This is called the 'worm-tub,' and contains the means for condensing the vapour after the latter has ascended from the still. This large vessel, which is between thirty and forty feet in height, contains a worm, or coil of copper pipe, circling round it in a screw-like form from top to bottom. The pipe is not much less than two feet in diameter where it enters the worm-tub, but gradually diminishes as it descends, till it leaves the vessel with a diameter of less than two inches. The vacant space of the worm-tub, not occupied by the pipe, is filled up with water, which is constantly flowing in from a water-tank, or 'liquor-back,' at the top of the still-house,—an overflow from the top being necessarily provided for. All the vapour which ascends from the still passes into and through this worm or coil of pipe, and in its passage becomes condensed into a liquid by the coldness of the water contained in the worm-tub. Whenever vapour is condensed into liquid, a large amount of latent heat is given out; and as this occurs during the condensation of the vapour in the worm, the water in the worm-tub becomes gradually heated, until at length its temperature would be such as to unfit it for the office of a refrigerator, were there not a constant supply of cold water flowing in, and an equal quantity of heated water flowing out. The rate of change is so regulated as to keep the water in the worm-tub at as low a temperature as possible. There is another arrangement of worm connected with one or two of the stills, although the principle is the same. We pass up through the still-house to the roof, and there find that a large area is occupied by tanks or square cisterns, through which cold water is constantly flowing from the reservoir. The pipe forming the worm coils round and round in these tanks, gradually parting with its heat to the water by which it is surrounded, and thus condenses the spirituous vapour passing through the worm from the still. By an ingenious arrangement the water, when too hot for the purpose of condensation, is allowed to fall on the float-boards of a large water-wheel, which thus furnishes moving-power for some of the pumps in the still-house.

The liquid which flows out at the lower end of the worm is called, in the language of the distillery, 'low-wines:' it is a very weak kind of spirit, containing all the alcohol previously existing in the 'wash,' mingled with a considerable quantity of water. As we shall now have to speak of the *strength* of spirit, it may be desirable to explain the nature of the standard employed by the Excise. Alcohol being of a lower specific gravity than water, a quart or any other quantity of the former would weigh less than an equal quantity of the latter; and any mixture of the two will weigh more or less according as the water or the alcohol predominates. The Excise adopts as a standard that particular mixture of alcohol and water whose weight bears to that of an equal bulk of distilled water at a medium temperature the ratio of twelve to thirteen: that is, supposing a given bulk of distilled water weighed thirteen ounces, then an equal bulk of standard spirit will weigh twelve ounces. This particular degree of alcoholic strength is called 'proof spirit,' and is the standard to which all other strengths are referred: it consists almost exactly of one-half pure alcohol and one-half water. The strengths of all mixtures of alcohol and water—called by the general name of *spirits*—are ascertained by means of their specific gravity, and this is determined by a hydrometer, of which that kind known as 'Sikes's Hydrometer' is used by the Excise. This instrument is capable of weighing all liquids as light as the strongest spirits of wine, or as heavy as water, and consequently all mixtures of the two. The scale of the instrument is graduated, and these graduations are said to be 'above proof' or 'below proof,' according as they indicate a degree of strength above or below that of 'proof spirit'; '100° below proof' is equivalent to pure water, while '70° above proof' is about equivalent to the strongest spirit ever produced by distillation. When the strength exceeds '43° above proof,' the liquid is known by the name of *spirits of wine*, and constitutes the strongest form in which spirit is presented to us, except in the refined operations of the chemist's laboratory.

These explanations will enable us to allude to the strength of spirits in the language of the distillery. We may proceed to state, then, that the 'low-wines' leave the worm of the wash-still at a strength very many degrees 'below proof,' in consequence of the large quantity of water mingled with the alcohol. The blue pipe which emerges from the worm-tub, and which contains the 'low-wines,' terminates in the curious piece of apparatus represented in Fig. 6. This apparatus is called the 'worm-safe,' and is intended to afford the means of testing the clearness and strength of the liquid flowing through it. The liquid flows from the end of the pipe into a hollow glass globe receiver, and from thence flows back through a larger pipe concentric with the former. By turning a small handle, a small portion of the liquid is made to pass into an upright cylindrical glass vessel two or three inches in diameter; and into this cylinder the hydrometer is introduced for measuring the strength of the liquid.



Worm-safe, or Hydrometer apparatus.—Fig. 6.

From the worm-safe the low-wines flow into vessels called 'low-wine receivers,' the stronger portion being allowed to flow into one receiver, and the weaker into another. These receivers, like all the other vessels employed in a distillery, are under the control of the excise-officer, who ascertains the quantity and the strength of the low-wines obtained by distillation. From the quantity and the specific gravity can be ascertained the amount of 'proof spirit' contained in the low-wines receiver, and this amount is entered as a check against the operations in other parts of the process.

The 'low-wines,' being much too weak for any of the ordinary purposes of spirit, have to be re-distilled, as a means of driving off a considerable proportion of water. This re-distillation is effected in other vessels called 'low-wine stills,' or sometimes 'spirit-stills.' But here some degree of complication occurs, of which we can only speak in a general way. Provided all the wash be distilled in the wash-still, and the product collected in the low-wines receivers, the Excise allows the distiller a certain latitude as to the subsequent distillations in the spirit-still. He may redistil over and over again, with a view to improve the quality of his spirit, or to economize ingredients, provided the officer can retain throughout the means of determining that all the spirit obtainable from the wash is ultimately collected in the spirits-receiver, and that none is so collected but what can be thus accounted for. This latitude seems to have been allowed to the distiller partly because a portion of the spirit, redistilled from the low-wines, possesses a disagreeable odour and flavour, which must by some means be removed, and which the distiller may devise the means for removing more effectually if allowed to exercise his judgment in the matter. These impure portions of the spirit, which are called 'feints,' or 'faints,' and which derive their peculiar quality principally from a fœtid oil yielded by the husks of the grain, are collected in separate receivers, and are thence reconveyed to the spirit-still to be redistilled. At this point in the proceedings, therefore, each distiller is enabled to exercise his judgment, and apply the results of his experience in the management of his distillery: hence, too, arise the distinctions between strong and weak 'low-wines,' and strong and weak 'feints'—distinctions made to further the views of the distiller. It will be sufficient for our present purpose, however, to state generally, that one distillation in the wash-still converts all the alcoholic portion of the wash into low-wines; and that one distillation in the spirit-still converts the greater part of the low-wines into spirits, the remaining portion requiring a third distillation.

We had occasion to speak of two different modes of condensing the vapour adopted at the distillery, and have now to describe a third. The spirit-still is surmounted by a tall copper cylinder, the interior of which contains a number of small pipes; cold water is kept constantly flowing through these pipes, so adjusted to the heat of the cylinder as to maintain a pretty constant temperature of 180° or 190°. Now as the vapour rises from the still into the cylindrical condenser, and comes in contact with the inner pipes, the aqueous portion falls down again into the still in the form of water, being unable to maintain the vaporic form when in contact with substances at so low a temperature as 190°. But the alcoholic portion remains in the state of vapour at that temperature, and passes off into the worm of the still, there to be condensed into spirit.

We have spoken only of one 'safe' for the exhibition and testing of the distilled product. But there are four such in the distillery to which our attention is directed: they are arranged two on either side of a convenient platform, raised a few steps above the floor of the still-room, and are adapted to receive the various kinds of 'low-wines,' 'feints,' and 'spirits,' as they proceed from the condensing-worms to the respective receivers.

The spirit-receiver is a vessel under the especial supervision of the excise officers, since the final adjustment of duty is regulated by the quantity and strength of the contents of this receiver. We have before stated that the officer gauges the quantity and specific gravity of the worts in the fermenting-back, and calculates the quantity of proof spirit which ought to be charged for therein, amounting to twelve gallons of proof-spirit from one hundred gallons of wort when the latter has a specific gravity of 1·060. He also gauges the quantity and strength of the proof-spirit in the 'low-wines,' in the feints, and lastly in the finished spirits, with a view to let one method act as a check to the other. The duty is paid on the actual quantity of proof-spirit in the spirit-receiver; but should this prove, on an average of a twelvemonth, to be less than the quantity estimated by the gauge of the worts or wash, the distiller has to pay up the deficiency: if, on the contrary, there is an excess, the Excise retains the benefit of that excess. It was stated in evidence given before a Committee of the House of Commons on Distillation, a few years ago, that the quantity of proof-spirit produced is generally rather over than under the quantity estimated from the wash; but that the estimate is a very near approximation as a general average. If the spirit in the receiver is 'over-proof,' an increased rate of duty is not charged, but the spirit is hypothetically increased in quantity to the requisite dilution, and then the duty applied. Suppose, for example, there is one hundred gallons of spirit 25° over-proof; this implies that if twenty-five gallons of water were added the mixture would be at proof; the distiller is thereupon charged duty on one hundred and twenty-five gallons of proof-spirit.

From the spirit-receiver, the spirit passes to the store-warehouse, a long building situated in the western part of the distillery. Here are ranged seven or eight large store-vats, numbered (as most of the vessels are required by law to be in a distillery) and inscribed with their liquid capacity. This store-room is provided with the requisite conveniences for filling casks from the store-vats, and for despatching them from the distillery. As spirit does not, like beer, improve by being kept in store for a considerable period, there is no necessity for that vast array of vats which forms such an object of wonder at the great porter-breweries; and as spirit is, bulk for bulk, twelve or fifteen times dearer than porter, a small establishment of barrels, waggons, horses, &c. will be adequate for the business of a large distillery.

RECTIFYING AND COMPOUNDING.

Let us now recapitulate the steps through which we have traced the production of spirit. In the first place the grain—consisting of any of the usual varieties, and either raw or malted—is crushed or ground, as a means of allowing hot water to act more readily on the farinaceous ingredient. In the next place this grain is mashed with water till a heavy liquid called 'worts' is extracted. Then the 'worts' are fermented, by which the saccharine principle is converted into alcohol; and lastly, this alcohol is, by repeated distillations, separated from the greater portion of the water with which it had been combined. The result is called 'plain British spirits.' But we have not yet done with it; we have yet to trace it through the hands of another manufacturer.

The liquid so highly valued in science as 'spirit of wine,' the various forms of spirituous liquors known as hollands, whiskey, gin, British brandy, &c., and the cordials known as peppermint, cloves, aniseed,

&c., are produced by the *Rectifier* from plain spirit purchased by him from the *Distiller*. This is a distinction which we have not hitherto had an opportunity of explaining. As a means of preventing any surreptitious proceedings in respect of duty, the excise laws prohibit the carrying on of two distilleries, or one distillery and a rectifying establishment, within a quarter of a mile of each other. They also limit the quantity of spirit which the distiller may sell to a minimum of eighty gallons at one time, with which must be given a 'permit.' As a general rule we may state that British spirit (we exclude mention of Scotch and Irish whiskey, as, although plain malt-spirit, they are regulated by clauses in the act applying specially to them) is but little known in the form in which it leaves the distillery, since it receives from the hands of the *rectifier* the peculiar properties by which it is rendered familiar. The person's name often attached to spirituous liquors, as a guarantee for the quality, is the name not of the distiller, but of the rectifier. There are only six distilleries in the vicinity of London, and, we believe, no more than nine in the whole of England; all the other establishments called by that name, being places where the spirit, made from the malt or grain by the distiller, is redistilled, 'rectified' or purified, and compounded with various vegetable substances to impart flavour.

Among the rectifying distilleries in the metropolis we have availed ourselves of permission to visit that of Messrs. Stephen Child and Son, in Trinity Street, Southwark, a peculiarly elegant and scientific establishment, in which the resources of modern science are brought to bear on the particular branch of manufacture with much tact and discrimination. This distillery has been recently erected on a plot of ground belonging, we believe, to the Trinity House; and in virtue of a stipulation that the building should be an architectural ornament to the spot, the exterior has been made one of the most highly decorated in that part of the metropolis: indeed its façade would bear comparison with most of the West-end club-houses.

This distillery consists of a square court-yard surrounded by buildings. The eastern, western, and southern sides comprise various offices and buildings of a subsidiary character, such as warehouses, waggon-sheds, stables, harness-rooms, &c.; while the northern side comprises the building in which all the operations of the distillery are carried on. This latter is surmounted by an ornamental chimney, which is likely long to retain its cleanly appearance, for nearly all the smoke produced by the furnaces is consumed; a principle, the further adoption of which in our manufactories would be a step of incalculable benefit.* We shall best describe the arrangement of the various parts of the building by tracing the progress of the spirit through them.

The raw spirit is sold by the distiller to the rectifier in two different strengths, viz. 25° over-proof, and 11° over-proof, both of which are rigorously fixed by the legislature. The spirit is brought to the rectifier in casks belonging to the distiller, with an excise permit; and an officer visits the rectifying distillery to see that all the spirits received there have paid duty: beyond this point the excise laws do not control the rectifier, except in one or two minor points. Supposing a cask of raw spirits to be conveyed to Messrs. Child's establishment, it is hoisted into a large square room called the warehouse, lined on two sides with rows of store-vats, and opening into the still-room. The cask is rolled upon a weighing-machine, which is connected to a very ingeniously constructed steelyard, whereby the weight of the spirit and cask is determined. The empty cask being afterwards weighed, affords the means of determining the exact weight of the spirit; after which a reference to a thermometer and to a printed table shows the exact number of gallons of spirit. The weighing-machine being level with, and indeed forming part of the floor, and the steelyard being portable, the necessity for heavy scales is wholly obviated.

When the full cask has been weighed, it is rolled over an opened trap-door in the floor, the bung is removed, an air-vent is opened, and the spirit flows out into a store-vat placed in the room beneath for its reception. This trap-door is provided with means for saving any alcoholic vapour which may rise from the spirit beneath. We next proceed to the underground vaults, where we see a range of store-vats for the reception of raw spirit, preparatory to the rectifying processes; and from thence we trace the spirit, by means of pipes, to the still-room, an apartment small in dimensions, but full of scientific appliances. On one side of this room we see a large iron tank, about thirty feet long and ten high: this is divided into four compartments, and serves as a worm-tank for containing the cold water with which the spirit is condensed. Immediately in front of this is a range of four stills, one for gin, one for spirit of wine, one for British brandy and British rum, and one for cordials. These stills are not heated by open fires, but by steam; a layer or thin stratum of steam being allowed to act on the lower half of each still, something on the principle of a sugar-boiler. The steam for this purpose is generated in two large cylindrical boilers, heated by smoke-consuming furnaces in which Merthyr Tydvil coals are burned, the steam-pipes being covered with non-conducting substances to prevent the loss of heat.

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* A society, having for its object the furtherance of Metropolitan improvements, is at the present time laudably engaged in impressing this most important subject on the attention of manufacturers; and, it is to be hoped, with a prospect of ultimate success.

Supposing the spirit is to be converted into gin, one of the stills is seven-tenths filled from the store-vats, and steam is admitted to act on the still. The contents ascend in vapour, which is afterwards condensed in the worm-tanks. This distillation is the *rectifying* of the spirit, by which a certain portion of essential oil is removed from it. Then ensues the *compounding*, which is a re-distillation with certain herbs, berries, and seeds, in order to impart the particular flavour whereby the liquid is known. Whatever may be the strength of the spirit when it comes into the hands of the rectifier, he reduces it, when in the form of gin, to a strength not greater than 17° under-proof.

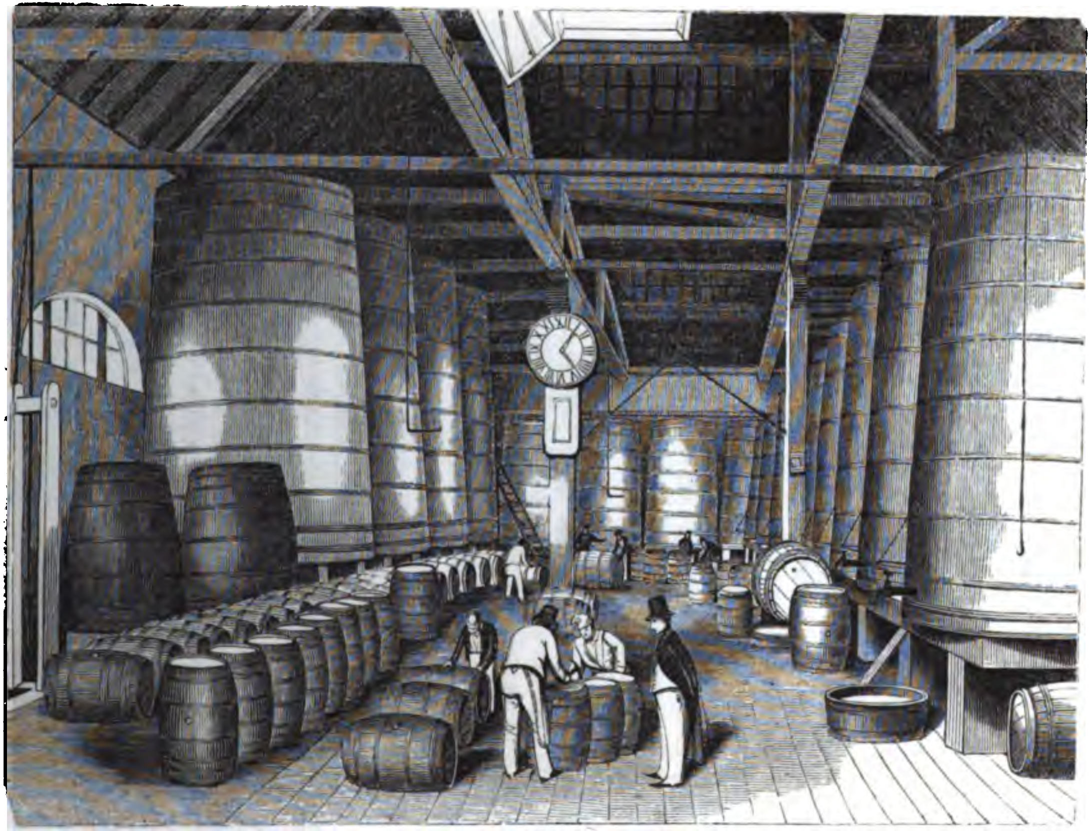
If spirit of wine is to be made, the crude spirit is pumped into a still whose upper part consists of a vertical cylinder, containing a large number of pipes. The vapour ascending these pipes, and the pipes being surrounded by water at about 180°, the arrangement effects (on the principle we have before explained) so extensive a separation between the alcoholic and aqueous vapour, that spirit can be obtained as high as 62° over-proof. It must, by law, be as strong as 43° over-proof; but the saleable strengths are from about 54° to 60°.

If British brandy, British rum, or cordials are to be made, the spirit is redistilled with various vegetable substances calculated to impart the requisite flavour. By an ingenious arrangement, patented, we believe, by Messrs. Pontifex, the alcoholic vapour, instead of condensing in the worm-tank, passes into a flavouring-vessel containing the ingredients, so as to imbibe the qualities of those ingredients while condensing: it is again converted into vapour, and then passes through the worm-tank, to be finally condensed in the usual way.

All the various liquors, as condensed in the worm, are conducted by pipes into store-vats contained in a different part of the building; but in their way thither they pass through hollow vessels called 'safes,' similar in object and in principle to those employed at Messrs. Smith's, but differing in construction. In the still-room is also kept a powerful hydraulic press, capable of exerting a pressure of a hundred and fifty tons: this is employed for pressing some of the fruits used in the preparation of cordials, such as raspberry and cherry-brandy. In the upper part of the building is a store-room for the cinnamon, peppermint, cloves, aniseed, juniper-berries, and various berries, seeds, and fruits used in the preparation of cordials, and in flavouring the various kinds of spirit, together with the requisite apparatus for preparing them for the still.

In every part of this establishment the arrangements for the economising of heat are very complete. We have said that the furnaces consume nearly all their own smoke. This is effected by supplying fuel in such a manner, that the smoke from the new coal must pass over highly heated fuel before it can reach the chimney, whereby nearly all the carbon is brought into profitable employment. The stills, too, are not only heated by steam, brought from boilers in pipes covered with non-conducting substances, but the heat of this steam when condensed is even saved. A small apparatus called a 'condensing-box' is placed in the still-room for this purpose, and acts as follows:—As fast as the steam, admitted into a hollow jacket round the bottom of each still, becomes condensed into water by the lower temperature of surrounding bodies, this hot water flows into a cylindrical cavity in which a heavy circular stone moves up and down. This stone is exactly balanced by a weight at the other end of a lever, so that a small power suffices to move the stone. The hot water, filling the space beneath the stone, gradually raises it, and in so doing acts upon a catch which opens a valve, and allows all the water to descend into the boiler in the room beneath. Thus all the heat contained in the condensed steam is effectually preserved.

The boilers, steam-engines, and pumps, employed in the various operations of the establishment, are all of the most modern forms, and are arranged with singular economy of space, each being placed within a very few feet of the spot where its power is to be practically applied.



IV.—'Sending-out Warehouse.'—Beaufoy's Vinegar-Works.—Face p. 65.

IV.—A DAY AT A VINEGAR AND BRITISH-WINE FACTORY.

There exists—not only between malt liquors and spirits, as explained in the last two articles, but between all the dissimilar liquids *beer*, *spirits*, *vinegar*, and *wine*—a connexion little supposed by the majority of those who use them. Who would expect, unless he had attended somewhat closely to the matter, that the same corn which yields our quartern loaves may be made to yield spirit, and beer, and vinegar, by particular processes? Or that wine, cyder, beer, malt, fruit, sugar, and molasses, are all capable of yielding—and many of them are actually made to yield, in manufacture—that very distinct and peculiar liquid, vinegar? These are remarkable instances of vegetable chemistry, or of the changes which heat and other agents produce in vegetable substances. The full explanation of all these changes forms one of the most difficult branches of science; but the manufacturing arrangements are capable of being described in a general manner, without involving the delicate and complicated reasonings of the chemical philosopher. Having, in connexion with the last two "visits," been enabled to describe the brewing and distilling processes and arrangements whereby beer and spirits are produced, we may now appropriately notice in a similar manner the Vinegar-manufacture. It happens, too, that the firm who have liberally afforded the facilities for this purpose, viz., Messrs. Beaufoy of South Lambeth, are not only malt-vinegar makers, but also manufacturers of "Sweets," or as they are more generally termed "British Wines." Thus the same visit will enable us to gather a little information respecting the production of wine.

The vinegar-manufactories are but few in number. There are reasons, applying to these establishments as well as to porter-breweries and distilleries, why competition cannot be carried to so great an extent as in smaller undertakings. The "plant," or assemblage of apparatus, is very costly, and the skill required in the manufacture considerable. In a Report presented by the Commissioners of Excise Inquiry a few years ago, it was stated that the number of vinegar-makers in the United Kingdom is forty-eight.

Of the five principal vinegar-works in the metropolis, four are situated on the Surrey side of the water. Messrs. Beaufoy's establishment formerly occupied the site of the present southern approach to Waterloo Bridge, and was removed thence to Vauxhall in consequence of the building of the bridge. The present works are located in South Lambeth, between Vauxhall and the Clapham Road, and occupy a considerable area of ground. In this, as in most other large works, the entrance gates open into a court-yard or area, portions of which are occupied by buildings wherein the manufacturing processes are carried on. Glancing along the left boundary of the court, we see, in the first place, an excise office, fitted up for the convenience of the officers always more or less in attendance at a vinegar-factory (as in distilleries, soap-works, glass-works, &c.) by whom the amount of duty accruing on the manufactured product is ascertained. Beyond this is the 'shipping department,' or counting-house for the management of all matters connected with the coasting trade and the reception of materials; and in front is a weighing-machine. Adjacent to this is the 'chemical-room,' for the prosecution of experiments, and the analysis of liquids, arising out of or connected with the operations of the establishment. Ranges of stabling occupy a further portion of this line of buildings; and the remainder consist of fermenting-rooms connected with the manufacture.

On the right of the court-yard are counting-houses and offices; beyond which the width of the court greatly increases. Immediately in front is the main building wherein the manufacture is carried on, and the successive stories of which exhibit a very varied assemblage of apparatus. Beginning at the top floor, we find this appropriated as store rooms, for the malt used in the vinegar manufacture, and the sugar and fruit for the wine manufacture. In various rooms and compartments of the upper part of the building are machines for grinding and crushing malt, fruit, and sugar, and all the arrangements antecedent to what we may term the *chemical* portions of the several processes. At a lower level we find, from the numerous pipes extending in all directions, that liquids are here brought to act upon the dry ingredients. Here, too, are large coppers or boilers for hot water; mash-tuns, similar to those used by brewers; and conduits for liquids both into and out of these vessels. On the ground-floor the apparatus marks a still more advanced stage of the manufacture: here are 'under-backs' and 'jack-backs,' a refrigerator or cooling machine, a range of fermenting tuns, another range of wine-presses, and other vessels and machines pertaining to the two branches of manufacture.

Beyond this building, which is known as the 'Brewhouse,' is another called the 'stoves,' or the 'stove-room,' kept carefully closed on all sides, and brought to a considerable heat within, for the furtherance of a very delicate part of the process of vinegar-making. Near this are buildings connected with one or two other branches of manufacture carried on by the same firm, which we shall not here notice further than to say that Messrs. Beaufoy are also 'millers' and 'drug-grinders.' A detached building in a more remote part of the yard serves as a store-house, the internal arrangements of which exhibit a specimen of very careful and minute classification. It is a feature in the establishment to make and repair on the premises as many of the implements and apparatus employed as possible. Hence a considerable quantity of materials is always in requisition; and these are under the especial control of a storekeeper. The whole of the buildings of the factory are classified into certain departments, each of which is placed under distinct superintendence; and the heads of the departments are charged with the quantity of stores and materials supplied by the storekeeper. The weight and number of all stores supplied being entered in a book, as well as the department to which they are supplied, the principals can thus at any time ascertain the amount of consumption in any one department. Lead and colours, brushes and pots, for plumbers and painters; nails and screws, &c. for carpenters; hoop iron for coopers; various tools and implements for smiths—indeed materials and tools for half a dozen different trades, are here congregated. Factory visitors may frequently notice this feature in large establishments, where a well-planned system of economy leads to the employment, within the factory, of a number of artisans not directly concerned with the manufacture carried on. All this is regulated by a well-known principle in the division of labour, which can only be developed where a large number of persons is employed.

Behind the store-house, and extending to a considerable distance, is the *vinegar-field*, a remarkable feature in most vinegar-works. Here the eye glances over many hundreds of casks, all ranged in parallel rows, and elevated to equal heights from the ground on wooden bars resting on brick piers. A pathway lies open between each pair of rows of casks; and at intervals in these paths are openings or valves, forming channels of communication, to which we shall allude more particularly hereafter.

Returning from the vinegar-field, we find on the south side of the open court the workshops for the various artisans alluded to above. There is one shop for blacksmiths, another for millwrights and engineers; another for plumbers, a fourth for carpenters, a fifth for wheelwrights. The cooperage is more extensive than any of these, for all the casks employed in the vinegar and wine departments are both made and repaired within the premises.. On the same side of the open court, but nearer to the entrance, are buildings more particularly connected with the staple manufacture of the place. One of these is called the *Rape-shed*, and is filled with numerous bulky vessels in which the finishing processes of the vinegar-manufacture are carried on; so bulky, indeed, that some of them admit of comparison with the giant vats at Barclay's brewery. Another of these buildings is the 'sending-out warehouse,' where the vinegar, after the completion of the manufacture, is consigned to store-vats ranged round the wall, and thence drawn off into casks for sale. The interior of this building is represented in Fig. 1. A somewhat similar building is the *wine store-warehouse*, where the British wines are stored and drawn into casks.

We may finish our tour of the premises by remarking that the water required for the establishment is furnished by an Artesian well; and that there are three steam-engines for pumping the water, pumping the liquids in various stages of preparation from one vessel to another, grinding the malt, &c. There is a range of waggon-sheds too; and two fire-engines for the protection of the premises. The large open areas of the court and the vinegar-field, with the various buildings surrounding them, together occupy about eight acres.

It may now be well, in attempting to describe the operations carried on in these buildings, to keep them wholly separate, and to offer what we have to say concerning vinegar, before we speak of British wine.

THE VINEGAR MANUFACTURE.

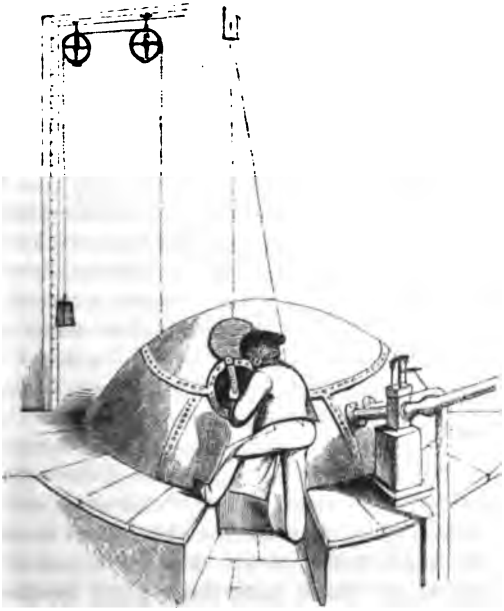
At the beginning of this paper it was stated that vinegar may be produced from many substances apparently wholly dissimilar. It is not only that they *may* be, but they *are* so in practice; for one manufacturer uses one ingredient, one another. Messrs. Beaufoy's is a *malt*-vinegar factory, where the vinegar is produced from precisely the same substance as that whence the Highlander makes his whiskey. The theory of fermentation is one of the most refined points of scientific investigation; but it may be remarked, as a general clue to the apparent discrepancies in the materials of the vinegar manufacture, that alcohol, or spirit, is capable of being distilled from sugar, from fruit, from grain, and other vegetable substances; and that whatever yields spirit, may also be made to yield vinegar, by a different mode of procedure. Indeed the acetous fermentation, whereby vinegar is produced, follows very closely on the vinous, whereby spirit results; and it is often difficult to stop at the one and prevent the occurrence of the other. When we hear of 'sour' beer or 'sour' wine, we may regard these as instances that the acetous fermentation has commenced, or that our beer or wine actually contains some vinegar; indeed the French name *vin aigre* (sour wine) points significantly to one source whence the acid is produced.

Dismissing any discussion of the question why one manufacturer selects one ingredient and one another, we proceed to the details of the malt-vinegar manufacture, as exemplifying most of the principles involved.

What constitutes malt is pretty generally known, and has been before alluded to; but it may be added here, that the process of malting changes the character of the grain by converting some of the starch contained in the barley into sugar, and facilitating the similar conversion of a further portion. This conversion into sugar, called the 'saccharine fermentation,' is one of the important steps in the preparation of beer, of ale, of whiskey, and of malt-vinegar: in all of these it is requisite that the starch of the grain be converted into a kind of sugar; for it is from this sugar that the vinous fermentation produces alcohol, the parent of vinegar. Hence the early processes in an ale-brewery, a malt-distillery, and a malt-vinegar factory are very similar.

The malt is brought to the vinegar-works which we are describing, and hauled up out of the waggons into the upper floors of the brew-house. Here openings placed in different directions allow the malt to be poured down into large bins, from whence it is removed when a brewing is about to take place. (Vinegar-makers and distillers, as well as ale and beer brewers, give the name of 'brewing' to the extraction of a saccharine liquor from malt.) The quantity required for one brewing being measured out, and taken from the bins in sacks, it is poured through 'hoppers,' or funnels at the top of the grinding apparatus, whereby the malt is reduced to meal. The apparatus consists of both the kinds used for such purposes, viz. mill-stones and crushing-rollers, either or both of which can be employed as may be deemed best. In the one case a flat circular stone rotates and crushes beneath it the malt which flows between it and a lower fixed stone. In the other case the malt, after flowing through a shoot or trunk from the hopper, falls on a wire grating, where it becomes separated from any impurities with which it may be mixed; and it then passes between two cast-iron rollers rotating nearly in contact, whereby it is crushed to fragments. An ingenious contrivance, invented by Captain Huddart, is adopted for yielding to any hard substance which may enter between the rollers with the malt, without injury to the apparatus: it acts on the principle of stopping the revolution of the roller altogether until the cause of obstruction is removed.

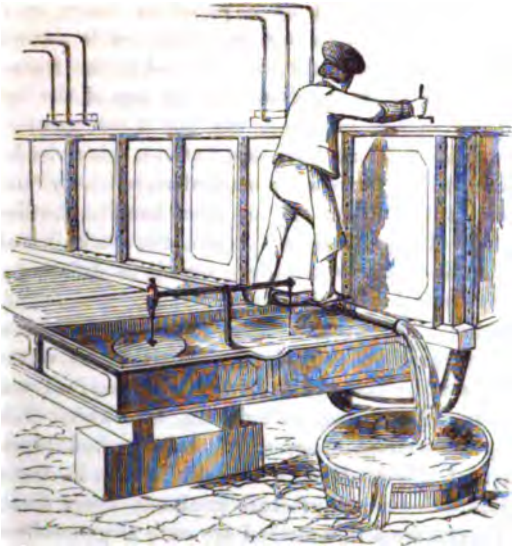
When the malt is crushed or ground, it falls through a hose or trunk into the mash-tuns in the floor beneath. These mash-tuns are similar in principle to those used at the great breweries and distilleries, but smaller in size. They are circular vessels with a central 'stirrer,' or instrument for keeping in constant agitation the ingredients which may be in the tuns; the stirrer being worked by a steam-engine. It is in these vessels that the 'saccharine fermentation' goes on, or the extraction, by the action of hot water, of a sweet or mawkish substance from the malt. It is this sweet principle which subsequently yields to the brewer his beer or ale, to the distiller his spirit, and to the vinegar-maker his vinegar; and it may well be supposed that every precaution is taken, and every investigation made as to the extraction of the greatest quantity and the most fitting quality of this important agent. The quantity of water required with a given quantity of malt, and the temperature at which the water is used, vary in each particular branch of manufacture, according to the strength of the 'wort' required. The arrangements at Messrs. Beaufoy's for adjusting these elements are very exact and ingenious. The hot water is let down upon the malt in the mash-tun when at the proper temperature; and in order to adjust this, the foreman of the brewhouse ascertains, by the aid of a thermometer, the temperature of the water, through a temporary opening in the upper part of the boiler. The arrangements at this spot are shown in Fig. 2, where is also represented



Upper part of the Copper or Boiler.—Fig. 2.

a balance-weight and graduated scale, which, aided by a float on the surface of the liquid in the copper, indicates the number of inches depth of water therein.

When the water has acted on the malt for a certain period, and been constantly stirred with it, the liquor receives the name of *wort*, and is allowed to flow through pipes out of the mash-tuns into a large cast-iron tank or 'underback,' measuring probably twenty-four feet in length, by eight in width. This is merely a general receptacle for the wort, into which the latter is collected when the mashing is completed. Then ensues the process of *cooling*, one which exhibits many remarkable differences as effected in different establishments. In the descriptions of a great brewery and of a distillery, we had to speak of large, open, shallow, airy rooms, called 'coolers,' or 'cooling-floors,' whereon the wort was poured in a thin layer to be cooled by the access of air on all sides. Such was formerly the mode adopted at the vinegar-works now under description; a surface of nearly twenty-three hundred square feet having been appropriated to this purpose. This mode has, however, been superseded by another, in which one hundred square feet of surface is made to yield the effects formerly wrought by more than twenty times that extent. There is a vessel now employed for this purpose called a 'refrigerator,' which acts on the following principle:—The hot wort is allowed to flow out of the underback into an oblong vessel, and out of this latter into another receptacle in the same part of the building. A continuous pipe, between three and four hundred feet in length, passes backwards and forwards through the oblong vessel, and through this pipe cold water is continually flowing from an Artesian well two hundred feet deep. There is a constant current of wort from east to west through the vessel, and a constant current of water flowing from west to east through the pipe; and it is not difficult to see that this must have a tendency to cool the wort. There are four adjustments by which the wort may be made to leave the refrigerator at any desired temperature, viz., increasing or decreasing the rapidity of the entrance of the wort, the exit of the wort, the entrance of the water, and the exit of the water. As the cold water travels onward through the convoluted pipe, it abstracts heat from the surrounding wort: when the water flows quickly, the wort is cooled to a lower temperature than when it flows more slowly; and by a simultaneous adjustment of the valves connected with the wort-vessel, the flow of the wort can be also duly regulated. Fig. 3 represents the refrigerator, at the end where the wort enters, and where the water leaves the pipe after having performed its office; by the side of the refrigerator is seen the 'underback.' Not only does this method require much less room than that of the 'cooling-floors,' but the time employed in cooling a given quantity of wort is reduced to one-third, and the manufacturer is rendered independent of fluctuations of the weather; for, unlike atmospheric agency, his cooling agent is brought from a source two hundred feet below the level of the ground, and is nearly equable in temperature at all times. It may be as well to remark that this method of cooling is the reverse of that adopted in the worm-tub of a distillery: in this latter case the hot liquid, or rather



Underback and Refrigerator.—Fig. 3.

vapour, passes through the pipe contained in the vessel, and the cold water flows through the vessel itself; but in the vinegar refrigerator the cold water passes through the pipe, and the hot liquid through the open vessel. The distiller's worm is not, in fact, a *refrigerator*, it is a *condenser;* and the condensed vapour must not be open to the atmosphere.

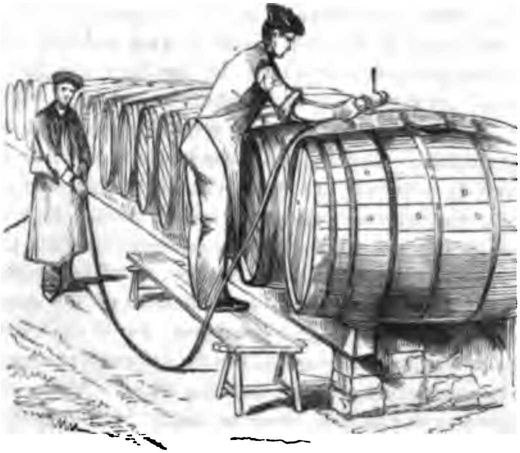
The reader will bear in mind that the wort thus produced is in principle precisely the same as that made by the ale and beer brewer and the distiller, differing only in saccharine strength. It undergoes, too, the same process of fermentation, subject to those limitations which may be required by the nature of the manufacture. From the refrigerator which we have just described, the cooled wort flows into a large circular receptacle sunk in the ground, called the 'jack-back,' from which it is pumped up into 'fermenting-tuns.' Here we may remark, that a valuable system of combination or centralization is observed in the arrangement of the conducting pipes in this establishment. There are here and there large vessels which serve as a kind of centre, from each of which openings lead to several other vessels, each opening being governed by a particular valve or cock. For instance, the liquid which in various processes is contained in the 'jack-back,' has sometimes to be transferred to the fermenting-tuns, sometimes to a large back or cistern at the top of the building, and sometimes to the copper; yet there are not three openings from the jack-back for these different purposes, but one, which leads to a three-barrelled pump, whose barrels are marked respectively 'tuns,' 'back,' 'copper;' so that by turning one of three handles, the liquid can be conveyed to one of these vessels. Again, the back just alluded to is placed in connexion with several large vessels in different parts of the premises, to any one of which its contents can be transferred by simply turning a handle. There is one of the buildings in which a hexagonal table is seen, under the bed or surface of which are six valves, or cocks, all opened and shut by one key. Each one is inscribed with the name of some one particular vessel or building, with which it is placed in connexion by an extensive series of underground pipes; and the superintendent of this small piece of apparatus can in fact control the flow of the liquid under manufacture in almost every direction. The advantages derived from this method are such as generally result from a union of centralization with classification.

To describe what goes on in the fermenting-tuns is no easy matter, as it involves the little-understood process of the vinous fermentation. The brewer, the distiller, and the vinegar-maker alike expose the wort to the action of yeast and an elevated temperature; but they require very different degrees of the alcoholic development. The brewer, when his wort has fermented, gives the name of *beer* or *ale* to the product, according to the manipulation of manufacture; the distiller calls his fermented wort by the name of *wash;* while the vinegar-maker applies the name of *gyle* to the fermented wort which he uses. It is very proper that distinct names should be thus used (although those actually employed may seem somewhat unmeaning); for the liquids are by no means the same, although all alike produced by vinous fermentation from sweet wort.

The fermented wort, or, as we shall now term it, the *gyle*, is transferred from the fermenting-tuns to other vessels, where it leaves a deposit or sediment, which is a kind of acetous yeast; and being thence allowed to flow into the jack-back, it is pumped up one of the branches of the three-barrelled pump into the large vat above. From this, as a centre, the gyle is allowed to flow into casks, where it assumes the form of vinegar, a process which is in every respect remarkable. The change here indicated is brought about in two methods exceedingly opposite in their general character. In the one case the casks containing the gyle are placed in close rooms heated to a high temperature; in the other they are ranged in rows in an open field, where they remain many months. Different as these methods seem to be, yet the effect produced is precisely the same, viz. the conversion of the gyle into vinegar by the internal process of acetification. In what manner the oxygen of the air and the heat of the stove-rooms work this change, is as much a chemical difficulty as the process of fermentation generally. As regards the convenience and interests of the manufacturer, both methods seem to have their advantages; for at the vinegar-works which we are describing both are followed, although the one occupies a very much longer period of time than the other. When the vinegar is to be acetified in the field, it must be made during the three spring months, and then left several months in the field.

This process of acetification is technically called 'stoving,' or 'fielding,' according to the method followed. In the first-mentioned case, the casks containing the gyle are arranged conveniently in three stove-rooms, which are closed and locked, and then exposed to a certain temperature till the acetification has been wrought. Two minutes' stay in one of these rooms is quite sufficient to convince a visitor that vinegar is in the act of formation, the suffocating acetous vapour being insupportable. The method of stoving is, we believe, generally adopted by the vinegar-makers of France, and appears to render the manufacturer more independent of the seasons than the field process.

The process of 'fielding' is much more visible, if we may use such a term, than that of 'stoving,' from the circumstances under which it is conducted. The casks, each of which contains rather more than a hundred gallons, are arranged in long parallel tiers, with their bung-holes open and uppermost. Beneath some of the paths which separate the rows of casks are pipes, communicating with the 'back' at the top of the brewhouse; and in the centre of each of these paths is a valve or cock opening into the concealed pipe. When the casks are about to be filled, a flexible hose is screwed on to this valvular opening, the other end of the hose being inserted in the bung-hole of the cask. Then, as the reservoir of gyle is many feet above the level of the casks, the liquid flows by its own pressure through the underlying pipe and the hose into the cask. A man guides the hose in the manner

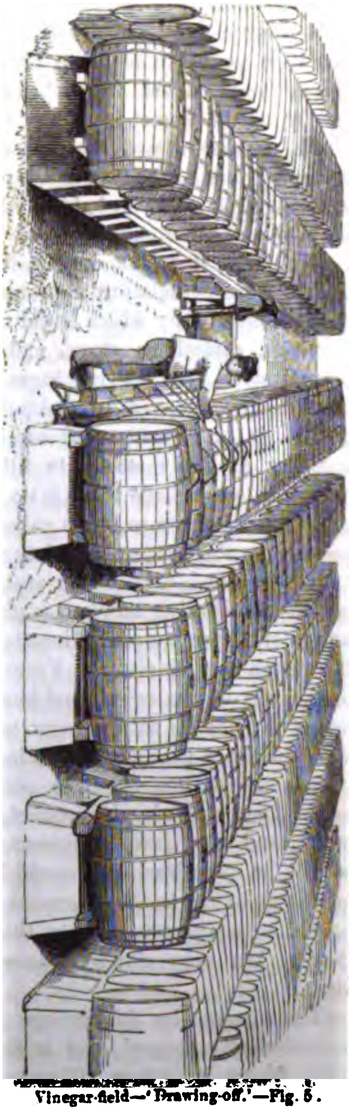


Vinegar-field—'Filling in.'—Fig. 4.

represented in Fig. 4, and has sufficient length of hose to fill all the casks in one row, one after another.

Here the vinegar remains for several weeks, or even months, the bung-holes of the casks being covered with small pieces of tile or slate, which are removed when the weather is fine. The casks are examined twice every day; and if it happens that a shower of rain comes on suddenly while the bung-holes are exposed, nearly all the hands in the vinegar department are 'turned out,' to cover the casks as speedily as possible. The air effects the same object as the heat of the stove-rooms, but much more slowly. In both cases the gyle, or fermented wort, undergoes the process of acetification, whereby it becomes converted into vinegar. In those factories where the vinegar is produced from other substances than malt, the gyle is converted into vinegar nearly in the same way as in the present case, although the gyle itself is differently produced.

When the 'fielding' is completed and the vinegar is to be removed from the casks, the arrangements are managed in a very ingenious manner. A long trough or shoot is laid by the side of one of the rows of casks, into which the vinegar is transferred by means of a syphon, the shorter leg of which is inserted in the bung-hole of the cask. The trough inclines a little from one end to the other, the lower end resting on a kind of travelling tank or cistern; so that the vinegar from several casks is collected in one tank. From the tank a hose descends to the valve placed in the ground, and the vinegar is drawn, by steam power in the adjacent buildings, from the tank into the hose, from thence into the valve, and then along an underground pipe, which terminates in one of the factory buildings. Thus the invisible moving-power is made to draw off all the vinegar from all the casks in succession. A portion of this operation is here represented.


Vinegar-field—'Drawing-off.'—Fig. 5.

The vinegar, so far as acetification is concerned, is now finished; but there is a certain purifying or cleansing required before it assumes a marketable state. This purifying is, however, not always done immediately; but the vinegar is pumped from the casks into a 'back of communication,' a centre from whence pipes conduct the liquid to a number of store-vats placed in the 'vat-warehouse.'

When the vinegar is to be clarified or 'brightened' for sale, it is pumped from the store-vats into vessels which are in some respects the most remarkable employed in the vinegar manufacture, or rather the clarifying ingredient is a remarkable one. In the 'rape-shed' are the enormous wooden vessels before alluded to, and known by the name of 'rapes,' each of which is filled with a filtering ingredient also called 'rape.' This double employment of the same word seems rather absurd; but it is probable that the 'rape-vessels,' or the vessels containing 'rape,' were called 'rapes' for the sake of brevity; and for the origin of the name itself we may perhaps refer to the French word 'raffe,' connected with the process of 'raffinerie,' or refining. Leaving etymology out of the question, however, we may state that this rape consists of *raisin stalks and skins*, which are said to filter the vinegar better than any other substance hitherto employed. It would seem pretty evident that it is not a mere filtration which the vinegar undergoes, but that in percolating over and over again through the rape, it imbibes some quality which it did not possess before. Sometimes wood-shavings, sometimes straw, and sometimes tanners' spent bark, is employed as the filtering ingredient; but the refuse of raisins which have been employed in making wine is preferred to every other material. It is a matter of immense difficulty to collect the necessary quantity of this material to fill the bulky vessels; and when once collected, we believe there is no part of the vinegar-maker's apparatus on which he places so much value. We shall have a few further details to offer on this subject in a future page.

Each 'rape,' or filtering-vessel, is fitted with a false bottom, on which the filtering medium is placed. Beneath this false bottom, and above the true bottom, is inserted a cock, which allows the vinegar to flow into a back or cistern. From this cistern a pump elevates the liquid to the top of the vessel, and hence ensues a very curious circuit; the vessel is filled up with vinegar, which filtrates through the raisin-refuse into the space beneath, thence into the tank, thence through the pump to the top of the vessel, to recommence its circuit. Over and over again does this circuit proceed, the pump being kept constantly at work, and the vinegar incessantly in motion. If such a comparison might be permitted, we would liken the pump to a heart, which propels the liquid to the enormous lung—the rape—where it is purified, and then again returned to the heart. The filtering substance gradually, but very slowly, wastes away, and is renewed from time to time.

The vinegar by this process becomes transparent, or 'bright,' as it is technically termed, and is then pumped from the rapes into store-vats, where it is kept till required to be put into casks for sale; and the rapes are immediately filled up with an equivalent portion of fresh vinegar, so as never to leave the raisin-refuse idle. The vinegar-casks hold one hundred and sixteen, fifty, and twenty-five gallons respectively. Each cask is examined and gauged before being brought into the 'sending-out warehouse,' to see that it is sound and of proper dimensions. The warehouse is a large room lined on all sides by store-vats, from which the casks are filled; and on the days when these casks are to be sent off, the warehouse presents a very busy appearance, with coopers, porters, &c. ranging the casks, marking them, and consigning them to the waggons.

With a few miscellaneous remarks on vinegar we must pass on to the other object of our 'visit.' Vinegar is known by certain numbers, such as No. 18, 20, 22, and 24. These originally represented the number of pence per gallon at which the vinegar was sold; and although the price no longer accords with these numbers, the numbers themselves have been retained as symbols whereby a certain quality of vinegar may be known and designated. Vinegar pays to government a duty of 2*d.* for every gallon of 'proof;' proof being deemed that degree of strength which contains five per cent. of pure acetic acid, as ascertained by an instrument called an 'acetometer,' which acts on the principle of determining the specific gravity of the vinegar when saturated with hydrate of lime, and deducing the acetic strength therefrom. Vinegar varies considerably in its strength under different circumstances, and the duty paid always bears a strict relation to the strength: thus, if the quantity of pure acid in a gallon of vinegar be double 'proof,' then it pays double duty, or 4*d.* per gallon; and so on. The strength of vinegar is more difficult to ascertain than that of spirit, for there is a kind of mucilage or extractive matter in it which increases its specific gravity, and which is very different in quantity at different times. Hence a given specific gravity will not, as in spirit, indicate the strength; and the test employed is the specific gravity *after* it has been saturated with hydrate of lime. Up to the year 1834 there were seventy-seven thousand dealers in vinegar in Great Britain, every one of whom was visited once a month by the Excise, to see that he conformed to certain regulations, such as to make an entry of his premises, and not to send out any quantity of vinegar exceeding ten gallons without a certificate from a book provided by the Excise. The expense of thus making nearly a million visits in a year, and the utter uselessness of the system, led to its abandonment in 1834, on the recommendation of the Commissioners of Excise Inquiry. The quantity of vinegar made in the British Islands is about three million gallons a year, of which more than half is made by four London firms.

BRITISH WINES, OR 'SWEETS.'

The use of British wines, or, as they are sometimes called, 'home-made wines,' is of very limited extent; and it may perhaps hardly have occurred to the reader that the manufacture is carried on on anything like a considerable scale. Such is, indeed, the fact at the present day; but still there are circumstances attending the rise and growth of this branch of trade too curious to be passed unnoticed.

It is perhaps pretty generally known that nearly all foreign wines are made from the juice of the ripe grape, and that the variations in quality and appearance depend partly on the species of grape, partly on the soil where it is cultivated, partly on the state of the climate, and partly on the method of vintage. British wines, however, are made either from dried grapes, which come to us under the name of *raisins*, or from common English fruits. At first the name of 'sweets' was confined principally to the varieties of raisin-wine; but as English-fruit wine was equally subjected to duty, all alike acquired the name of 'sweets.' The Excise definition of sweets is, "all liquors made by infusion, fermentation, or otherwise, from fruit or sugar, or fruit and sugar mixed with other materials;" and until 1834, any person who had any such liquor in his custody, in quantity exceeding one hundred gallons, was deemed a maker of sweets for sale, and subject to Excise survey.

The rise of the British-wine trade was closely connected with the vinegar manufacture, and dates back to about a century ago. At that time—as Hogarth's print of 'Gin Lane,' and many other sources of information, amply attest—the scenes of drunkenness witnessed in the metropolis had reached a fearful extent. The legislature endeavoured by various means to give a turn to the public taste that might lessen the evil; and among other things they held out strong inducements for the manufacture of sweets, or home-made wines, for sale. For many years, however, although sweets had been reckoned among exciseable articles ever since 1696, the manufacture continued utterly insignificant.

It happened about that time that Mark Beaufoy, a member of the Society of Friends at Bristol, who had abandoned his original trade of a distiller from conscientious scruples, arising out of the prevailing vice of the times, went to Holland to learn the process of malt-vinegar making; and on his return established a vinegar-factory on the site of the once-celebrated *Cuper's Gardens*, near the present southern end of Waterloo Bridge. The works grew in extent and in fame, and were visited many years afterwards by Pennant, who in his 'London' gives the following paragraph:—"There is a magnificence of business in this ocean of sweets and sours, that cannot fail exciting the greatest admiration, whether we consider the number of vessels or their size. The boasted tun at Heidelberg does not surpass these. On first entering the yard, two rise before you, covered at the top with a thatched dome; between them is a circular turret, including a winding staircase, which brings you to their summits, above twenty-four feet in diameter. One of these conservatories is full of sweet wine, and contains fifty-eight thousand one hundred and nine gallons, or eighteen hundred and fifteen barrels, of Winchester measure: its superb associate is full of vinegar, to the amount of fifty-six thousand seven hundred and ninety-nine gallons." The casks and hogsheads seemed to Pennant so minute after these, that he "imagined he could quaff them off as easily as Gulliver did the little hogsheads of the kingdom of Lilliput.*"

But to return to the 'sweets.' Mark Beaufoy, in the endeavour to establish a malt-vinegar factory, had to encounter a great difficulty, viz. the want of '*rape*' wherewith to construct the filters to fine and flavour the vinegar. In Holland the vinegar-makers were supplied with the refuse from the raisin-wine manufacturers and raisin-wort distillers; but in England there was no source of the kind whence he could be supplied, and yet such a supply was indispensably necessary to the success of the process on the Dutch method. Under these circumstances he was constrained to purchase raisins, and after steeping them for the purpose of extracting the saccharine and mucilage of the fruit, the liquor was thrown away, and the rape alone (comprising all the solid parts of the raisin) reserved for use in the vinegar manufacture.

It happened, however, that Dr. Fothergill, the Quaker physician, became acquainted with this waste of raisin-juice, and, after demonstrating how wine might be made from it, advised Mark Beaufoy to commence it as a branch of manufacture. He did so, and entered his name at the Excise as a "maker of sweets," about a century ago. From that time, owing partly to the spur which one branch of manufacture thus gave to another, and partly to a wish in many quarters to substitute a milder drink for that which had produced such social evils, the raisin-wine trade rose into distinction and importance. The kinds of raisins he used were principally Smyrnas, Malagas, Lexias, Faros, and Cape de Verds; but in later years the manufacturers of sweets included the English fresh fruits among the materials whence they produced wine. For forty years the trade gradually extended; but in 1784 the minister of the day adopted a course which most seriously shook and injured it: this was by enacting that no dealer or vendor of *Foreign wines* should be allowed to have any *British wines* upon his premises or in his possession; the two trades (of vendors, but not makers) having hitherto been considered and conducted as one. This enactment arose out of certain excise regulations concerning foreign wines; but its effect on the sale of British wines was most marked. In the year ending 5th July, 1784, previous to the new regulation coming into force, the duty charged upon sweets, in the London district only, was for 7000 barrels made by the firm of Beaufoy and Co., and about an equal quantity by the other makers who had by degrees entered the trade; whereas in the following year the quantity was only 241 barrels! The new act completely annihilated all the dealers, so far as this article was concerned, by rendering them obnoxious to heavy penalties; and the manufacturers had new connections to seek for vending their produce. The blow once given was never wholly recovered; for though the firm mentioned above paid nearly 10,000*l.* duty in 1813 on British wines, being the largest ever paid by one house in one year, yet the trade on the whole progressively declined, and was still further injured by the reduction of the duty on Cape wines some years ago. At length, by the year 1834, the duty became so small,—amounting to less than 3000*l.* per annum for the whole of the British Islands,—that the Commissioners of Excise Inquiry recommended it to be abolished altogether, as not worth the trouble and expense of collecting. British wines, therefore, are not now an exciseable article; and there will not in future be data whereby to judge whether the manufacture increases or diminishes.

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* Pennant's 'London,' 3rd edit., p. 34. Wilkinson, too, at a later date, gave a representation and description of these premises, in the 'Londini Illustrata,' as they appeared before the removal of the establishment to South Lambeth in 1812, consequent on the preparations for making the southern approach to Waterloo Bridge.

As a notable branch of trade, we may thus consider that the British-wine manufacture has gone through the phases of rise, zenith, and fall within about a century, although it may perhaps happen that the removal of the duty will give another impulse to it. It will still continue to be an interesting, though not an extensive branch of English manufacture; and those who are not so well provided with the good things of life as to have the real juice of the grape at their table will probably still, to some extent, look to a substitute less costly than foreign wine and less injurious than ardent spirits.

The manufacture of 'sweets' is one partaking of fewer processes than that of vinegar, and may be described without much difficulty. If we take the term 'sweets' in its fullest extent, so as to include all the varieties of British wine, then we shall at once state that the only variety claiming description here is that of *raisin-wine*, to which the manufacture was in the first instance confined. All the kinds made from English fruits, such as 'currant-wine,' 'raspberry-wine,' 'elder-wine,' &c., are such household acquaintances, that we need not trace their birth and parentage; every 'Cook's Oracle,' and 'Complete Housewife,' and 'Kitchen Manual,' and 'Useful Receipt Book,' and 'Guide to Service,' teaches us how to make these wines; and the difference between their methods, and the mode pursued by those who make the wines for sale, lies rather in the quantity operated on, and the size of the vessels, than in the routine of processes. Let us then glance at the method of making the wines from foreign dried fruits, as practised at this establishment.

The dried fruits or raisins (frequently, but erroneously, called *plums*) which result from the different kinds of grape, do not lose all the vinous quality of the fresh fruit, although much seems to be lost in the process of drying. Nearly all the grapes thus prepared are brought from the countries bordering on the Mediterranean, and are generally named either from the places where they are produced, or those whence they are imported; but in some cases, such as 'muscatels,' 'blooms,' 'sultanas,' 'raisins of the sun,' and 'lexias,' the name is derived from the quality of grape or the mode of preparation. The most simple mode of preparation in the grape-countries is to dry the fruit, after being cut when fully ripe, by exposure to the heat of the sun on a floor of hard earth or stone. Another method is to cut the stalk half-way through when the grapes are nearly ripe, and leave them suspended till the watery part is evaporated; the flow of sap is in a great measure prevented from entering the fruit, in consequence of the incision; and whilst evaporation continues to go on undiminished, the grape necessarily becomes dried. Some sorts are prepared by dipping the grapes in a ley, and afterwards drying them in the sun, the ley being formed of water, wood-ashes, and a small portion of oil of olives. Inferior raisins are dried by the artificial heat of an oven.

The raisins acquire very different qualities according to these modes of treatment; but the wine prepared from them by the British manufacturer of 'sweets' may be spoken of in general terms, without reference to specific differences, further than to say that the 'Lexias' produce a dry wine, the 'Denias' a sweet wine, the 'Black Smyrnas' a strong-bodied wine, and the 'Red Smyrnas' and 'Valencias' a rich and full wine. The time when the importer lays in his store of dried fruit is from Michaelmas to Christmas; and from thence to spring, or in short during the cool weather, is the principal time for making the wine.

The fruit comes into the hands of the wine-maker in three different kinds of packages—baskets, casks, and boxes—according to the quality of the fruit; but in general the raisins are packed closely together, and form a hard mass. These masses are in the first instance laid on a floor and beaten with wooden mallets, as a means of separating the raisins one from another. Sometimes the agglomeration is so close, that the mass has to be passed between rollers before the separation can be effected. The separate raisins—or rather the small masses, for the individual separation is not yet effected—are steeped in a vessel with a quantity of water, where they stand until all the fruit, by being swelled with the water, rises up and floats on the surface.

When the fruit has risen to the surface of the water, a portion of the latter is drawn from the vessel, by which the mass of fruit necessarily sinks to a lower level. A perforated board or floor is then laid on the top of the fruit in the vessel, and kept down by a weight; and upon this is pumped the liquor which had been previously drawn from the vessel. As the weight keeps the board down, and the board keeps the fruit down, it follows that the fruit has a body of liquid above as well as below it; while the perforations in the board allow the liquid to percolate through to the fruit. This process is repeated from time to time, by drawing off the liquid from beneath the fruit, and pouring it in above, by which all parts of the fruit become equally affected. The extraction which is brought about during this process probably begins at the moment when the fruit has lightness enough to float on the surface of the liquid, and continues throughout the process.

When all the vinous and saccharine matters have been extracted from the fruit by this process, the liquid is drawn off into separate vessels. The fruit, however, is not wholly exhausted by this drawing-off, for a considerable portion of the liquid is absorbed by and mixed up among the spent fruit. To recover this is a point of importance; and the action of pressure is here brought into requisition. In one of the rooms of the factory is a powerful hydraulic press, and also a range of screw-presses, the former or the latter being used according to circumstances. Fig. 6 represents one of these presses while being worked, by which it will be seen that considerable power is applied. Each press consists of a kind of cubical box, two or three feet square, into which a strong square board or presser works, being attached to a screw above, and the screw being turned by capstans. In the first instance a man gets into one of the steeping-tuns, and lades out the spent fruit into baskets, which are carried to the press-boxes

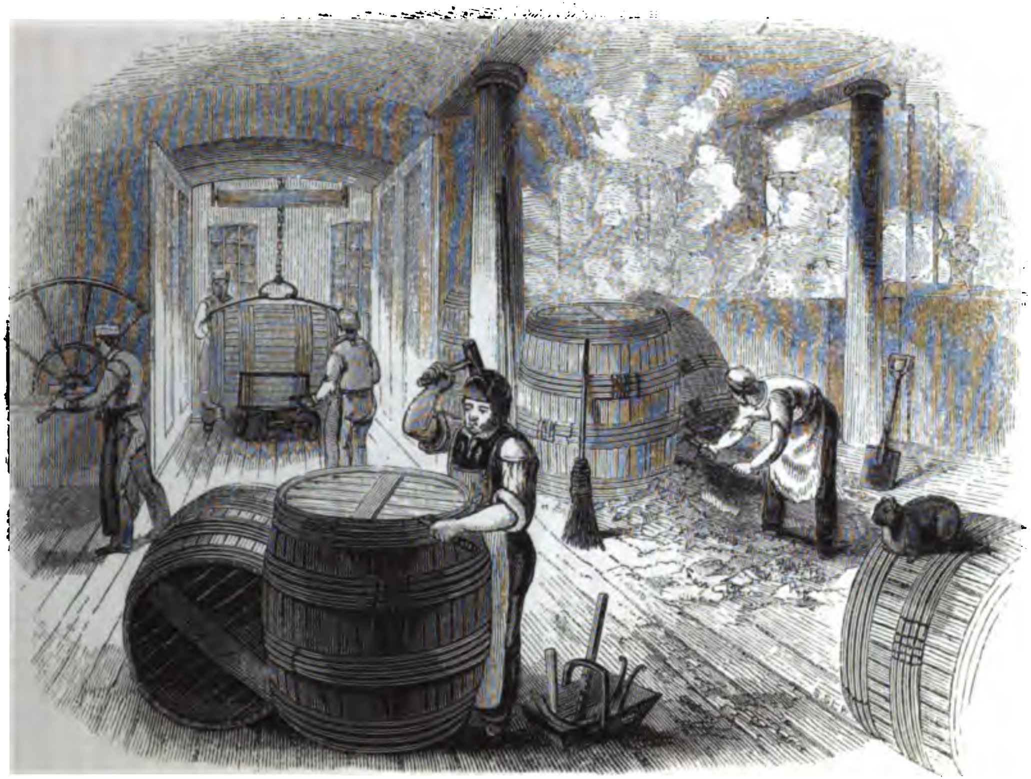
Wine-manufacture—Fruit-pressing.—Fig. 6.

and there thrown in until the box is full. A powerful iron bar is inserted in a hole in the screw-shaft, and is then used, capstan-like, to turn the screw and press the fruit, half a dozen men being thus employed. Sometimes the aid of a powerful windlass is employed to turn the screw; and the pressure thus exerted is so great as to reduce the fruit to one-third of its former bulk.

The liquid which is thus obtained is added to that which was drawn off from the steeping-vessels; while the spent fruit, now pressed almost dry, is so far from being valueless, that it constitutes the article *rape*, so important to the proceedings of the vinegar manufacturer. The steeping is not the only process which is carried on in the large vessels: for after the fruit has been moistened and the saccharine qualities extracted, a kind of fermentation is induced by a leaven or yeast contained in the fruit itself; and it is principally to regulate this fermentation that the liquid is passed so frequently through the mass of fruit. In fact the liquid which is drawn off from the vessels is not merely raisin extract or juice—it is wine in a crude state.

The wine is pumped from the fermenting-tuns into other vessels in the 'wine store-warehouse,'—a large building lined on every side with vats, tuns, and casks of various sizes. Here it is subjected to repeated 'rackings,' by which everything that is capable of being precipitated is separated from it and falls to the bottom of the vessels. Here, too, all the processes of sweetening, and 'fining' with isinglass, &c., according to the different kinds of wine, are carried on, until the wine assumes the form in which it is sold. It is stored in vats, from which it is drawn into casks for sale to the dealers. There is no 'bottling' department at this factory, the wine being sold 'in the wood;' and the dealer separates it into the smaller portions which find their way into the hands of the consumer.

Here we take our leave of this region of sweets and sours. The connection existing between these two branches of manufacture, both in history and in practice, has rendered it advantageous to treat of them both in one article; and the firm to which the foregoing details relate is the only single one which affords facilities for so doing.



V.—Interior of a Sugar-Refinery.—Face p. 89.

V.—A DAY AT A SUGAR-REFINERY.

If it were allowable to personify the East and West ends of London, we might consider them as strangers who have occasionally heard of each other's existence, but who, from the wide interval between them, have had little mutual acquaintance. The dweller at the 'Court end' of the town may, perhaps, have heard of 'Aldgate Pump,' as a spot remotely east, beyond the regions of the Bank, the Exchange, and the Mansion-House; and may, without the aid of a map, be in some doubt as to what exists still farther eastward. But he who would form an adequate idea of the metropolis in all its length and breadth, must be prepared to hear of a vast population,—a very world of human beings,—beyond the point to which we allude.

It is to this eastern district, and to one particular part of it, that we beg to direct the reader's attention in the present article. Most persons have heard of the occupation of a Sugar-refiner,—often, though erroneously, termed Sugar-baker,—that is, one who prepares the white conical lumps or loaves of crystallized sugar familiarly known as 'loaf-sugar.' Now, the buildings or 'refineries' in which this operation is carried on are not only situated in the east of London, but most of them are congregated within a circle of half a mile radius immediately eastward of Aldgate. Those who would seek for a reason why so many members of one trade or manufacture settle near each other, may be reminded that Oriental bazaars exemplify this custom to a remarkable extent, and that the object is principally to afford facilities to purchasers. At Constantinople, Bagdad, and other Eastern cities, each of the principal trades has its own bazaar,—one for jewellery, one for silks, one for spices, and so forth; and purchasers know at once what part of the city to visit when any commodity is required. In London, the admixture of trades and professions in most trading streets is now such, that the bazaar method is little observable (for the motley 'bazaars,' commonly so called, scarcely come within the proper meaning of the term); but still, whoever notices the assemblage of sugar-refiners in the neighbourhood of Goodman's Fields, the wool-combers in Bermondsey Street, the coach-makers in and near Long Acre, the watch-makers in Clerkenwell, the statuaries in the Paddington Road, and many similar instances, will not fail to observe indications of this custom, and to attribute it to some sufficient motive. Proximity to docks and warehouses furnishes a principal motive in the first-mentioned instance. Whether the sugar-refineries have, ever since their introduction into England, been located in this district is not exactly known, but such would seem to be probable. Stow, in the following remark, does not make mention of any particular part of London:—"About the year 1544 refining of sugar was first used in England. Then there were but two sugar-houses; and their profit was but little, by reason there were so many sugar-bakers in Antwerp, and sugar came thence better and cheaper than it could be afforded at London. And for the space of twenty years together these two sugar-houses served the whole realm, both to the commendation and profit of them that undertook the same."

Sugar-refineries have certain peculiarities in their external appearance, whereby they are distinguishable from most other factories: they are very lofty, consist of an unusual number of floors or stories, and are lighted by rather small windows. In the sugar-refinery of Messrs. Fairrie, which we have recently visited, these peculiarities are very observable. Nearly two hundred windows may be reckoned in the exterior of the mass of buildings, most of them small, and some at such a height as to have seven floors or stories between them and the ground. The interior, too, has something peculiar in its appearance, arising from the shallowness of the rooms compared with their great extent: these rooms are very numerous, nearly square, and no higher than is absolutely necessary, since the chief desideratum in a sugar-refinery is a large extent of flooring. The greater part of this building is formed of iron, brick, and stone,—a very necessary precaution against fire, on account of the inflammable nature of the article manufactured.

Most readers are probably aware that 'lump' or 'loaf' sugar,—a holiday luxury to the middle classes, and, hitherto, an unattainable one to the humble,—is prepared from common brown sugar by a refining process, and that this process is conducted in the buildings to which we have alluded. In describing the mode of operation, we shall not find it necessary to trace the history of sugar in its previous states; but still a few remarks thereon will aid the object in view, by showing the successive conditions or forms in which the sugar is presented.

The supply of English sugar is mostly obtained from the West Indies, where the sugar-cane is, as is well known, cultivated to a vast extent. "A field of such canes," says Mr. Beckford, "when standing in the month of November, when it is in arrow or full blossom, is one of the most beautiful productions that the pen or pencil can possibly describe. It commonly rises from three to eight feet or more in height, a difference of growth that very strongly marks the difference of soil or the varieties of culture. It is, when ripe, of a bright and golden-yellow; and where obvious to the sun, is in most parts very beautifully streaked with red. The top is of a darkish-green; but the more dry it becomes, from either an excess of ripeness or a continuance of drought, it assumes a russet-yellow colour, with long and narrow leaves depending; from the centre of which shoots up an arrow, like a silver wand, from two to six feet in height, and from the summit of which grows out a plume of white feathers, which are delicately fringed with lilac dye, and indeed is, in its appearance, not much unlike the tuft that adorns this particular and elegant tree." Such is the external appearance of the plant yielding the sugar-juice. By a succession of processes, effected on the sugar plantations, the canes are cut and crushed, the juice boiled, evaporated, and granulated into the form of moist or brown sugar, which is finally packed in hogsheads and exported. The material on which so much capital and so much slave-labour are annually expended, assumes three forms before it reaches England: it is first a juice expressed from the cane; then a kind of syrup, from which impurities have been removed; and lastly a brown granulated substance, from which a considerable portion of molasses, or uncrystallizable sugar, has been removed.

The ponderous sugar-hogsheads which we notice at the shops of the retail grocers contain moist sugar somewhat resembling in quality that which is imported by the refiner, but with a finer and softer grain. This sugar, as every housewife familiar with the qualities of 'sevenpenny' or 'eightpenny moist' is aware, has various shades of brown colour, according to the quality; and the principal cause of this colour is, that a quantity of black molasses, or treacle, which formed part of the original cane-juice, is still mixed up with the crystallizable parts of the sugar,—not having been wholly removed by the processes to which the cane-juice is subjected before importation. The particles of sugar in their pure state are white; and to present them in this white crystalline form is the object of the sugar-refiner, who adopts means for expelling the molasses, and also certain impurities which are incorporated with the brown or Muscovado sugar as imported in the hogsheads.

It seems probable that the art of refining sugar was first introduced into Europe by the Venetians, and was practised in Venice some time before it was adopted in any other European country. The foul and black sugar brought from Egypt, at the end of the thirteenth century, was the first material upon which the art of the refiner was employed. The Venetians, in their first attempts, converted the dark moist sugar into sugar-candy; but they soon sought to obtain refined or crystallized sugar by a quicker and more profitable process, which they at length effected by the use of conical moulds, such as have ever since been used. From Venice the art passed into various European countries; and since America has been so fertile in the production of sugar, refineries have increased to a considerable extent in England and other countries.

Let us suppose, then, that a hogshead of moist sugar, imported from abroad, is brought to a refinery, and let us follow it through the routine of processes till it assumes the form of a conical lump of white sugar. This will enable us to describe the uses of the various buildings and rooms forming a large sugar-refinery, taking as our guide the one before alluded to, viz. that of Messrs. Fairrie, Brothers, and Co., situated nearly behind Whitechapel Church.

This refinery consists mainly of two ranges of buildings, in the eastern of which the earlier and in the western the later processes are conducted. The hogsheads of sugar, having been brought in waggons from the West India Docks to the east side of the refinery, are hauled up by a crane, and drawn in at an open door to a large square room. This was the first part of the building which we visited, and a busy scene it presented: here was a hogshead of sugar, suspended from the crane, and just on the point of being drawn into the warehouse; there was another hogshead, deposited on a low iron carriage, and being wheeled farther inwards; near it was a third, being weighed, —a process requiring tackle of no slight kind, since the hogsheads, when filled, vary from four to eighteen cwts. each; farther on was a man knocking out the head of a hogshead, and a party of others emptying the contents on a boarded floor; while other hogsheads, some empty and others full, were lying around in various directions. Our frontispiece represents the appearance of these objects.

The sugar, when about to be operated on, is transferred from the hogsheads to a wooden floor, from whence it is shovelled into large circular vessels called 'blow-up cisterns.' If we gave a literal acceptation to technical terms, we should sometimes smile, and at other times feel a little alarm: in the present case it appears that the name is given in allusion to the mode in which steam is admitted to the contents of the vessels. The cisterns are six or seven feet in diameter, and about five in height; and the purpose for which they are employed is to dissolve the sugar preparatory to the removal of earthy and other impurities with which it is contaminated. The reader must bear in mind that notwithstanding the purifying processes whereby cane-juice is converted into brown sugar, there are still three kinds of substances which require to be removed from this sugar before the white crystalline state can be obtained, viz., earthy and other impurities, colouring matter, and molasses; and that very distinct processes are resorted to in order to effect the removal. To remove the impurities is the first object. The sugar is, as before stated, thrown into the 'blow-up cistern;' and water is admitted to it from a cistern at the top of the house, which supplies every part of the establishment, and which is, in its turn, supplied from a well nearly two hundred feet deep, worked by a steam-engine. Into the cistern containing the sugar and water is pumped a small quantity of lime-water. A steam pipe, in communication with a boiler at the east side of the building, is enclosed within the 'blow-up cistern;' and apertures being opened, steam is forced or 'blown' by its own pressure into the solution, by which the latter becomes heated in a very short space of time. This is one of the many instances in modern manufactures illustrative of the advantages derived from the use of steam as a heating agent. The water in the 'blow-up cistern,' being heated by the steam, dissolves the sugar, aided by constant stirring by means of long poles or oars. The lime-water, which aids in this process, is brought from vessels situated in the eastern part of the premises: they are casks broader at the bottom than the top; and the lime being dissolved in water and stirred till a milk-like fluid is produced, the lime-water is pumped from them as wanted.

This part of the process is one in which great improvements have been made of late years: indeed the same, to a certain extent, may be said of nearly all departments of the refining business. Under the old mode of proceeding, the sugar was dissolved in lime-water over an open fire, whereby it was subjected to a variable temperature injurious to the quality of the sugar: the clarification was effected by the admixture of a large quantity of bullock's blood, and a scum several inches in thickness was allowed to collect on the surface of the vessel containing the sugar, and was thence removed by a broad skimmer. As an illustration of the effect of the albuminous refining substance, *i.e.* the blood, we may refer to the action of hot water on the white of an egg, which is almost pure albumen; the white coagulates, or becomes solid, in two or three minutes. If any liquid containing albumen be mixed in another liquid and heated, the albumen, in the act of solidifying, collects together in a sort of film, and in so doing appears to entangle most of the solid impurities floating about in the liquid, removing them from the liquid generally. The addition of bullock's blood, and the process of skimming, having been repeated two or three times, the solution of sugar was allowed to flow through a wooden channel into an oblong basket covered with a blanket, through which it filtered into a cistern below, carrying a considerable portion of impurity with it. But, in the modern process, the desired effect is produced in a much more efficacious manner; for the temperature of the solution is not greater than that of boiling water, and the offensive clarifying ingredient is almost entirely dispensed with, the process of clarification, or the removal of impurities, being principally effected in the next process.

The saccharine solution—called in the language of the refinery 'liquor'—is not skimmed at all; but, at a certain stage in the operation, it is allowed to flow from the 'blow-up cistern' into a range of filtering-vessels in a room beneath, into which filters it enters as a thick, opaque, blackish liquid, and leaves them in a beautifully transparent state, though coloured of a reddish hue. The arrangement of these filters is exceedingly ingenious. Several cast-iron vessels, about six feet high, contain each sixty cloth tubes, about three inches in diameter, attached to short metallic tubes which are screwed to circular holes in the upper part of the vessel, and hanging vertically downwards. Each tube contains a large bag, made of a close kind of cotton cloth, and coiled up so as to make the whole a compact mass of cloth; and the bags being each two feet wide and six feet long, it is easy to calculate that there are nearly fifteen hundred square feet of cloth comprised in each filtering-vessel. The 'liquor,' then, flows from the 'blow-up cisterns' into a shallow vessel to which these tubes are attached, and thence through the bags contained in the tubes. The bags being closed at the bottom, no outlet exists for the liquid except through the meshes or interstices of the cloth; and as the cloth forming each bag is doubled and re-doubled in its tube, the liquid finds its way between the plies or folds of the cloth, and finally exudes in a transparent state. The whole of the impurities, with the exception of a little colouring matter, are retained by the bags and tubes, while the saccharine liquor passes through.

It must be evident that the impurities left in the bags would soon clog the meshes, if not removed. At intervals, therefore, the tubes are unscrewed, and taken out to a washing-yard, where the bags are drawn out, the impurities removed, and bags and tubes thoroughly washed. These impurities still contain a small portion of saccharine matter, which is subsequently extracted from them by boiling and other processes; and the spent residue is finally sold as manure, for which it possesses valuable qualities.

The next point in our visit is to the rooms in which the process of 'decolouration' is carried on. The reader will bear in mind that the state to which the sugar has been traced in its progress is that of a transparent liquid having a reddish tinge. To remove this tinge, without interfering with the transparency of the liquid, is the next object of attention; and charcoal is the agent which modern inquiry has shown to be best fitted for this purpose. It has been long known that common wood-charcoal possesses the property of removing, more or less, the odour proceeding from animal and vegetable substances in a state of decomposition; but it was also discovered by the German chemist Lowitz, that the same substance will remove the colour from common vinegar and several other liquids: a fact which soon afterwards led to the employment of charcoal in the clarification of various pharmaceutical preparations, and as an auxiliary in the refining of sugar. About thirty years ago, M. Figuire, of Montpellier, ascertained the additional important fact, that charcoal obtained from animal substances is not only equally efficacious when used in considerably smaller proportion than vegetable charcoal, but that it is capable of decolouring many liquids on which the latter has no sensible effects whatever. The sugar-refiners immediately availed themselves of the knowledge of this fact; and since that time many different modes have been adopted of employing animal charcoal in refining.

What is meant by 'animal charcoal' is the earthy and carbonaceous product obtained by burning bones in retorts; certain other ingredients in the bone are driven off by the heat, leaving an intimate mixture of phosphate and carbonate of lime with carbon, which then obtains the name of animal charcoal. It is not well known in what manner charcoal acts on the colouring particles of bodies; but Mr. Aikin, in one of his Lectures, makes the following remarks on the comparative action of vegetable and animal charcoal:—"It is certain that the more finely divided any given weight of charcoal is, the more powerful is its decolouring effect; and thus the inferiority of those kinds of charcoal that break with a glossy fracture, when compared with those of a dull fracture, is accounted for: the particles of the former being assumed to be nearly solid, and those of the latter to be porous, or, in other words, more minutely divided. In bone or animal charcoal the carbonaceous particles are separated from each other by the large quantity of earth with which they are mixed; and hence the superiority of this to vegetable charcoal resolves itself into a case of very minute division." These points, however, are not yet settled.

We return, then, to the operations on the sugar, which we had traced through the filtering-bags. All the liquor, as it leaves the filters, flows through pipes into other parts of the building occupied by charcoal-cisterns, each of which is a square vessel, four or five feet in height, and provided with a double bottom, the upper one being perforated with small holes. On this perforated bottom a piece of cloth is laid, and on the cloth a layer of powdered animal charcoal, or 'bone-black,' nearly three feet in thickness. The saccharine liquor flows on the surface of this charcoal bed, through which it slowly finds its way, percolating to the bottom, then through the meshes of the cloth, and lastly through the perforations into the vacant space beneath. The effect of this filtration is very striking; for the liquor, which, though transparent, is of a reddish colour when it flows into these cisterns, leaves them in a state of colourless transparency almost equal to that of pure water. Such a complete decolouration is the best proof of the success of the modern improvements in this branch of manufacture. The cloth bags, and the arrangements by which the liquor is made to flow through them, remove all the opaque impurities; while the charcoal, and the apparatus of which it forms a part, remove the colouring matters from the filtered liquor.

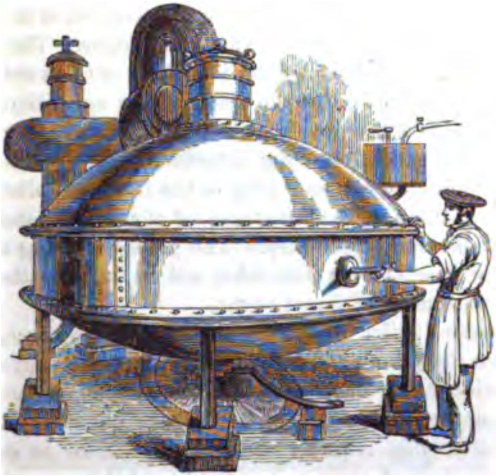
In the eastern part of the premises is situated a retort-house, supplied with furnaces, retorts, and various subsidiary arrangements. These, whose use might, to a stranger, appear rather inexplicable in a sugar-refinery, exemplify one of the most curious and valuable properties in the charcoal employed. When the process of decolouring the sugar has rendered the charcoal impure, water is poured through the mass in the cisterns, until all the soluble part of the saccharine impurities is removed; after which the charcoal is removed from the square cisterns, carried to the retort-house, put into iron retorts—of which there are a large number, each eight or ten feet long—and there re-burned. The arrangements for this purpose are on a considerable scale, and very complete; and the process is so conducted that the charcoal leaves the retorts in a state as fit for use as when it was first made; all the impurities having been burned away, without any deterioration in the decolouring qualities of the charcoal. Thus the same portions of charcoal may be used over and over again. This decolouring process was first employed in this country on a large scale by Messrs. Fairrie, who likewise adopted the mode here described of recovering the power of animal charcoal, several years before it became publicly known.

Every one knows that 'loaf' sugar, as well as 'moist,' possesses different degrees of whiteness and clearness of appearance. The mode in which these different qualities arise will be explained presently; but we may here remark, that it is only the finest qualities which present the pure and colourless appearance alluded to above, after passing through the charcoal. The inferior kinds retain a slight tinge of colour.

We next transfer our attention to that part of the building in which the most important of all the operations is carried on, viz. the boiling. If we were to attempt a description of all the inventions and contrivances which have been brought to bear on this process, it would not only absorb too much space, but would involve scientific details unsuited to our purpose: it must suffice to show how the method usually adopted at the present day differs from the old one, now almost obsolete.

The 'liquor' consists of sugar capable of assuming a crystalline form,—molasses, or uncrystallizable sugar,—and water; and the object of the boiling is to drive off a portion of the water in the form of steam, and to prepare the sugar for crystallizing. Under the old system the saccharine liquor was poured into a large copper vessel called a 'pan,' and there boiled over an open fire, at a temperature gradually rising to 230° or 250°, until the evaporation had caused it to assume a degree of viscidity known by experience to be proper for the purpose. From the pan it was emptied into vessels called 'coolers,' where it was beaten violently with an oar or staff, by the action of which the sugar was so far disentangled from the molasses as to be able to granulate, or become partially crystallized. It was found, however, that, independent of other evils, the sugar was liable in that process to be injured by the high temperature at which it boiled: for there is a tendency to decomposition even at the temperature of boiling water; and at a still greater heat the tendency is increased. These circumstances led to the happy suggestion, by Mr. Howard, of a method of boiling the sugar *in vacuo.* In the common operations familiar to daily experience, boiling water is always nearly of one temperature, because it is exposed to a tolerably uniform atmospheric pressure; but if this pressure could be removed by the action of the air-pump, or some other means, boiling would take place at a temperature so low that the hand could bear immersion in the water with impunity. So likewise in the case of sugar-liquor: if the pressure of the atmosphere could be removed, the process of boiling, which is nothing more than a very rapid evaporation, would take place at so low a temperature that the sugar would not be injured by it, viz. from 130° to 150°, that is, one hundred degrees lower than under the atmospheric pressure. Such were Mr. Howard's views; and few scientific suggestions have ever been attended with more complete success. Nearly all the principal sugar-refiners now boil sugar *in vacuo* more or less perfect; each one adopting a form of apparatus or a routine of processes best suited to the circumstances under which he conducts his business. We shall presently make a few further remarks on the introduction of this plan; but it will be desirable first to trace the sugar through the boiling process.

The pans at Messrs. Fairrie's refinery are circular, domed, copper vessels, from six to seven feet in diameter, and nearly the same in height. No fire is visible beneath them; indeed throughout the refinery we saw scarcely a symptom of a fire: whether the purpose be to heat a vessel of water, to boil the sugar in vacuo, to heat a stoving-room, or to warm the buildings generally, the heating power is supplied by steam, which traverses almost every part of the premises in pipes. Each pan is completely covered in, air-tight; but there are many channels of communication with other vessels: one admitting liquid sugar to the pan; another furnishing a channel through which it may flow out; a third admitting steam for boiling the sugar; and a fourth serving as an exit for the air originally contained in the pan, and also for the steam evaporated from the sugar. Various pieces of mechanism are attached to each pan, whereby the temperature of the liquid, the quantity contained in the pan, &c., may be tested; but these need not be further particularized. The external appearance of each pan, and the appendages belonging to it, are seen in Fig. 2.



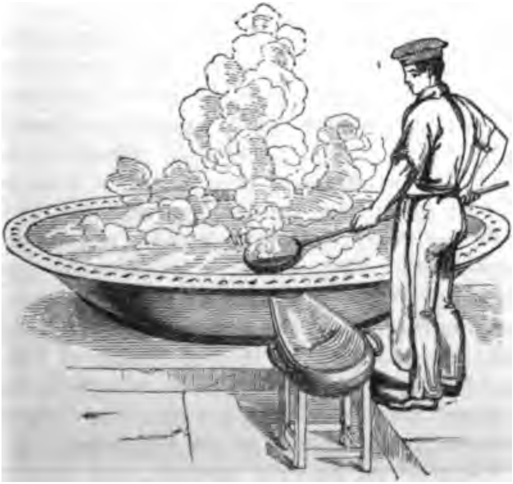
Sugar-pan or Boiler.—Fig. 2.

The process, then, is briefly this:—The liquid sugar, after percolating through the charcoal, and being collected in a cistern several feet below the pans, is placed in communication with them by an ascending pipe; and the air being withdrawn from within each pan by means of an air-pump, the liquid sugar ascends the pipe into the vacuum by atmospheric pressure from without, on the same principle as the water ascends in a common pump. Steam is then admitted to a vacant space below the sugar in the pan, and also through pipes traversing the interior; and by these means the sugar is brought to a boiling state while comparatively at a low temperature, on account of the tolerably perfect vacuum existing above the surface of the liquor in the pan. As the evaporation proceeds, the vapour flows through a large iron pipe into an open court, where a cistern of cold water condenses it as fast as it is formed, and thus maintains a vacuum within the boiler. The sugar, by this evaporation, thickens, and becomes partially granulated or crystallized; and to ascertain how far this process has extended, a most ingenious instrument, called a 'proof-rod,' is used, by which a small quantity of sugar may be taken out without disturbing the vacuum in the pan. This 'proof-rod' may be regarded as a key which unlocks a little valve in the body of the pan, draws out a sample of sugar, and locks the valve again. A hollow tube is fixed in the pan, with the outer end exposed to the atmosphere, but the inner end immersed in the liquid sugar. This inner end is constructed with a socket and plug, like the key of an ordinary liquor-cock, with two apertures, through which, when open, liquor may flow. The 'proof-rod' is a straight brass rod with a handle, having a key at the farther end, which, on being introduced into the tube and turned round, unlocks the socket and plug in the tube, and allows the liquid sugar to flow through the apertures of the socket and plug into a recess at the bottom of the key. The proof-rod being again turned, locks up the apertures in the tube, and on being withdrawn brings with it a small sample of liquid sugar.

The attendant 'boiler' then tests the state of the sugar, by taking a little between the thumb and finger, and trying what degree of tenacity and granulation it has acquired. If the result is not satisfactory, the boiling is continued for some time longer; but if satisfactory,—and this is a matter that requires constant experience to determine,—a valve at the bottom of the pan is opened, and the sugar flows through a pipe into a room beneath, where vessels are placed for its reception. The sugar, as it flows through, appears to be much altered, for it is now a mass of crystals enveloped in a dark-coloured syrup. All the pans are nearly alike in their mode of arrangement, and the reader will understand that the purpose to which they are applied is to drive off, in the form of vapour, so much of the water which has been mixed with the sugar as to enable the latter to crystallize. The steam employed as the heating agent is brought from a large boiler in the eastern part of the premises, which similarly supplies many other departments of the building.

One of the most marked points of difference between the old and the recent methods of boiling is this:—that, under the old system, the temperature at which the concentration was carried on was so high that crystallization could not take place till a subsequent cooling had been effected; whereas under the system introduced by Mr. Howard, the crystallization actually takes place, to a considerable extent, in the boiler itself. It was nearly thirty years ago that Mr. Howard took out his first patent respecting sugar-refining; but, like many other improvements, it made its way slowly into favour among manufacturers. The experiments on which he grounded his plan were made with a small table apparatus; and when, through an arrangement with a refiner in a large way of business, the method was put into practical operation, it was found to produce indifferent sugar, with weak, soft, and small crystals. After many attempts, however, all the practical difficulties were overcome; pure, large, and bright crystals of sugar were produced by the new method; and many refiners, both in London and elsewhere, adopted the patent process, for the use of which they paid a stipulated annual premium. There were some years in which the premiums thus paid by several refiners collectively amounted to more than forty thousand pounds per annum.

We resume our description. After having witnessed the operations and apparatus connected with the boiling, we next followed the pro-



Sugar-heater.—Fig. 3.

gress of the sugar to a room on the lower floor of the building, containing vessels called 'heaters,' into which the sugar flows from the pans. It is a curious circumstance, that under the old system the corresponding vessels were termed 'coolers,' as being at a much lower temperature than that at which the sugar was boiled in the pans; but they are now called by an opposite name, because the sugar is here raised to a temperature of about 180°, having previously been boiled at 135° or 140°. While being raised to this higher temperature, the sugar is kept constantly stirred; and at a certain point in the process it has acquired a state which renders further heating unnecessary. The object of this process is not so much to crystallize the sugar (for that has already been effected in the pan), as to impart to it a consistence which facilitates the subsequent processes, and gives to the loaf of sugar a firmer texture.

Recalling to mind what has been already stated, it will be seen that the sugar has been successively deprived of its solid impurities, its colouring-matter, and of some of the water which had been mixed with it; but the molasses, or uncrystallizable parts of the sugar, still remain. To separate these, therefore, is the object of the next few processes, technically termed 'filling out,' 'washing,' and 'netting.'

The 'fill-house,' the part of the refinery to which our visit next led us, presented a singular appearance. It is a very large square room, on the basement story, paved with stone, and having brick walls and ceiling. A considerable portion of the floor was covered with iron conical moulds, about two feet in height, and six inches in diameter at the largest part; each one placed with its apex downwards, and upheld by those with which it was surrounded. Hundreds, and probably thousands, of these moulds were thus ranged in close rank and file; some filled with sugar from the 'heaters,' others in the act of being filled, and the rest empty, waiting to be filled at a subsequent part of the day's operations. These were the moulds which give the well-known 'sugar-loaf' shape to the masses of white sugar seen at the shops of the grocers. Among the improvements which the business of sugar-refining has undergone, is the substitution of iron moulds for those made of clay; the latter used to be universally employed, but the former possess many advantages, and have almost superseded them.

A busy scene presented itself in the 'fill-house.' A number of men, each stripped from the waist upwards, were engaged in filling the moulds with liquid sugar from the 'heaters,' each man carrying

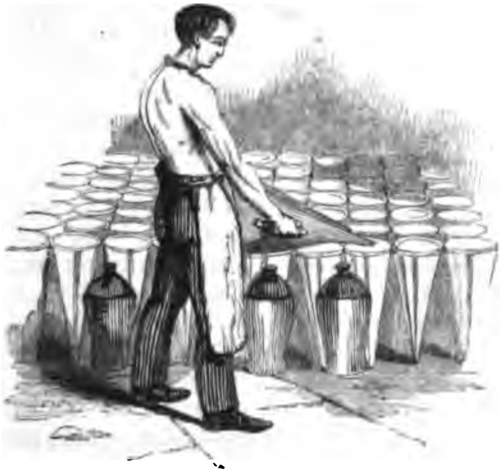


Fig. 4.

before him a large copper basin shaped somewhat like a coal-scoop, and capable of holding above a hundred-weight of melted sugar. The men went to the 'heaters,' filled their scoops with the hot viscid sugar, and walked, or rather ran, with a quick elastic motion, to the moulds, which they filled one after another with the sugar. Each man, as soon as he had exhausted his cargo by filling three or four moulds, hastened back to the 'heaters,' obtained another supply, and returned to fill other moulds. In witnessing this operation, it appeared strange that the men were not scalded, by the liability of the sugar being spilled from the vessels; but practice enables them, by a peculiar spring of the body, to hasten along at a tolerably quick pace, without much personal inconvenience from the heated sugar. As it is important to have all the sugar poured into the moulds while in a certain state of temperature and granulation, a sufficient number of men is employed to 'fill out' all the contents of one sugar-boiling in about half an hour. The operation, while it lasts, is a laborious one, and is generally undertaken by stout, hardy sons of the "Emerald Isle." When the moulds are filled, and the contents still in a fluid state, the surface is stirred and scraped round the edge of the sugar, to prevent any adhesion to the mould, and also to enable the small crystals which are forming to diffuse themselves equably through the sugar.

These moulds, then, contain sugar and syrup mixed up together, in a heated and viscid state; and in the 'fill-house' they remain till the following day, in order that two effects may be produced, viz.: the solidification of the sugar in the act of cooling, and the partial separation of the syrup from it. When these objects are to a certain degree effected, the moulds are taken, one by one, to a place called the 'pull-up hole,' in order to be passed to the upper floors of the building. With the usual brevity of technical language, the term 'pull-up hole' designates the mode of transfer. This hole is a vertical space, fifty or sixty feet high and four or five square, with ledges occurring at distances of every few feet in height, on which boards are placed to serve as platforms. A doorway opens into this 'pull-up hole' at every story; and the moulds containing the sugar are handed up one by one through the hole, each man taking the moulds from the man next below him, and depositing them in some one of the upper rooms. The moulds differ greatly in size and capacity; the smallest, when filled with liquid sugar, weighing only twenty-five pounds, and the largest, for the inferior kinds of sugar, weighing as much as one hundred and fifty pounds: of the larger kinds, therefore, the weight is too great to allow the moulds to be handed up in this way, and they are hauled up by means of a rope.

While the sugar is thus being conveyed to the upper stories, we will imagine ourselves to have ascended a spiral staircase which traverses the whole height of the building, and to have entered the 'washing' and 'netting' rooms. An extraordinary area of flooring is exhibited by these rooms. We have said that most sugar-refineries are lofty and consist of a great number of stories; and we are now in a condition to see the necessity for this. Every mould-full of sugar requires several days for its final completion; and thus each mould is in use so long, that a very large number is required for the purposes of the establishment, and many separate stories are necessary to contain them. In going from room to room, and from floor to floor, we saw repetitions of the same arrangements, viz., moulds ranged nearly all over the floors of the apartments, as thickly as they could stand: there could not have been less than from fifteen to twenty thousand of them filled with sugar, besides those which were waiting to be filled.

The processes which the sugar undergoes in these upper rooms must next be noticed. A small opening being made in the apex of each mould, the mould is placed in an earthen jar, where it is left for some time. During this period the syrup flows or drops out slowly through the perforation into the jar beneath. When this draining has proceeded to a certain extent, the mould is taken out of the jar; and the syrup, under the name of 'green-syrup,' is emptied from each jar into one common funnel or pipe, by which it is conveyed down to the boiling-house. As this syrup still contains a portion of crystallizable sugar, it is boiled over again with raw sugar, to produce lump sugar of a rather inferior quality; and when all the crystallizable sugar is obtained from it, the residue becomes the well-known substance *treacle*.

This draining, however, does not remove all the syrup from the sugar, a portion being still entangled among and coating the crystals; and to separate this portion, the sugar is 'washed' in rather a peculiar way. Formerly a process of 'claying' was adopted: a stratum of fine white clay diluted with water being laid on the surface of the sugar, the water percolated through the sugar by its own weight, mixing with the syrup which yet remained in the body of the sugar, and washing it away through the orifice in the apex of the mould. By the modern improvements, this porous surface, or sponge, as it may be considered, is formed of sugar instead of clay. The rough and uneven surface of the sugar on the base of the mould is scraped off into a vessel, and there mixed with water to the state of a 'magma' or mortar, which is again laid on the surface of the sugar. When this magma has acquired a certain degree of dryness, a clear solution of very fine sugar in water is poured on it, and allowed to remain. This solution, finding its way slowly through the mass of sugar beneath, carries with it the greater part of the syrup still remaining, together with a portion of good sugar which unavoidably accompanies it. This richer syrup, technically called 'second runnings,' is emptied from the earthen jars into a funnel which conveys it to the boiling-house, again to be boiled for the separation of the sugar from the molasses. The solution of the sugar is renewed from time to time, until the syrup is so thoroughly washed away as to leave the loaf of sugar in a beautifully white state; or if the sugar be of a cheaper quality, until a corresponding degree of purity has been attained. The substitution of sugar for clay as the sponge-like layer placed in the moulds, is one of the many improvements introduced by Mr. Howard; and its importance is shown by the fact, that the process is now effected in one-fourth of the time which it used to occupy under the old system.

A medium kind of sugar, called 'clayed,' or Lisbon sugar, is much used in some foreign countries, and forms a link between moist and loaf sugar. The brown cane-juice, at a certain stage of the process, instead of being put into hogsheads, is placed in conical pots, called by the French 'formes,' with the points downwards, having a hole about half an inch in diameter at the bottom, temporarily closed with a peg. When the sugar in these pots is cool, the apex is opened, and the pots placed over jars. After this a 'claying' process is pursued, nearly similar to that alluded to above. The result of this process is, that after remaining fifteen or twenty days in the moulds, the sugar assumes a form more white and pure than that of raw sugar, but less so than refined. But it appears probable that this old method will not be much longer pursued.

Returning to the refining processes, it will be evident that the quantity of syrup which drains from the apex of each mould is very considerable. In the first place, there is the 'green syrup,' which flows as soon as the hole in the apex is opened; and afterwards there are the finer syrups, resulting from the solution of fine sugar which is poured on the loaf or lump in the mould, and which carries off a portion of good sugar together with molasses. The subsequent boiling and preparation of those syrups, in order to obtain the crystallizable sugar from them, is almost as important an affair as the refining of the original brown sugar. A curious scale of qualities is maintained in these arrangements. The finest syrup is mixed with other sugar to obtain refined sugar of the same quality as that from which the syrup was obtained; the second quality of syrup assists in the preparation of sugar one degree lower in quality; whilst the coarsest, or 'green syrup,' produces a kind two degrees lower. Thus the finest syrup from the finest sugar is almost as pure as the sugar itself; while the coarsest syrup from the coarsest sugar is so thoroughly exhausted of crystallizable particles, as to be dismissed from the refining processes, and sold as treacle.

The face of the sugar in the moulds becomes rough and uneven, from the subsidence of the solid parts of the solution. When the 'washing' or 'netting' (*i. e.*, making the sugar net, neat, or pure), therefore, is completed, this face is made smooth. A man places the mould on its side across a stool, or trough, as in Fig. 5, and scrapes the base or open surface of the sugar with a small instrument: the process is called 'brushing-off,'—one of those odd technical terms which so puzzle a stranger, from their apparent inapplicability. The sugar is then allowed to remain a day or two in the mould, in order that the base may acquire hardness and firmness. A smart blow or two of the edge of the mould against a wooden post loosens the sugar within, and the loaf is turned out upon its base, after having lain in

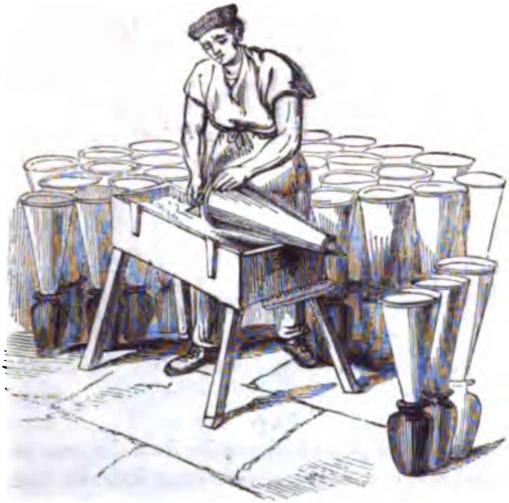


Fig. 5.

the mould for several days. We are then enabled to see the effect of the cleansing processes which the sugar has undergone: the surface is hard, crystalline, and more or less white according to the quality, the finest quality having a degree of whiteness almost rivalling that of snow. In no part of the manufacture have the modern improvements produced more decided effects than in the purity of colour now obtained. The inferior kinds of sugar retain a tint more or less dark, probably from the impossibility of expelling all the molasses from them.

The loaves or lumps (in the language of the refinery, 'loaves' are the finest quality, and 'lumps' somewhat inferior) of sugar are not, however, equally white all over when they leave the moulds, the parts near the apex being slightly damp and discoloured at the surface. To remove this damp portion, an ingenious machine is employed. Three cutting knives or blades are ranged in a conical form, and made to rotate by the motion of a wheel; and the apex of the loaf of sugar being introduced into the cavity formed between these blades, as in Fig. 6, the surface is shaved or sheared off, leaving the body of the loaf clean and smooth. Some of the larger and coarser lumps of sugar are not treated in this careful manner; but the damp apex is merely chopped off, leaving the lump as a truncated cone. The operation of shearing the surfaces of the loaves is termed 'turning off;' and the waste sugar ob-

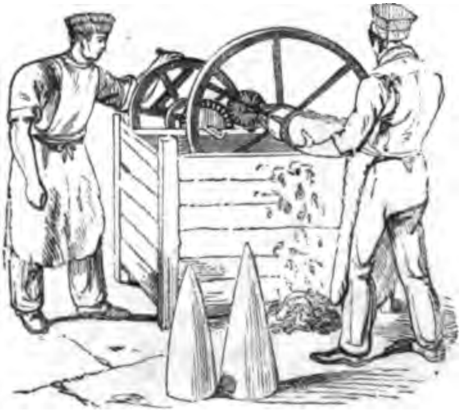


Fig. 6.

tained thereby, as well as that which results from the process of 'brushing off,' is melted and clarified, and converted into the fine clear solution which is poured on the sugar for the process of 'washing.'

After the loaves have been left several hours, ranged over the floors of large rooms, they are taken up one by one, wrapped in paper, and placed in an oven or stoving-room. This oven is one of the most singular parts of the building: the temperature maintained therein—about 140°—is too great to allow a stranger to remain long in it; but we saw sufficient to show the ingenuity of the arrangement. It may be characterized as a room about ten feet by eight, and sixty feet in height, provided with tiers of shelves at intervals of every two or three feet, and having several doors, one over another, in the side, each door opening into one of the ranges or stories of 'netting-rooms.' The lower part of this room or oven—for we may call it either—is occupied by a mass of steam-pipes, so extremely numerous, that the united length of the whole would probably not be less than half a mile; and the heat which the steam communicates to these pipes, radiating from their surface, raises the temperature of the air in the room, and causes a current of heated air to ascend to the top. When a large quantity of sugar is to be put into this oven at one time, the temperature is lowered by opening the doors, so as to enable the men to remain in it: they stand on platforms placed across the space at various heights, and range the loaves on the surrounding shelves.

In these ovens or stoving-rooms, of which there are three, all of great height, in different parts of the refinery, the loaves and lumps of sugar remain until they are thoroughly dried; after which they are taken out and wrapped in blue paper, in which state they may be deemed finished.

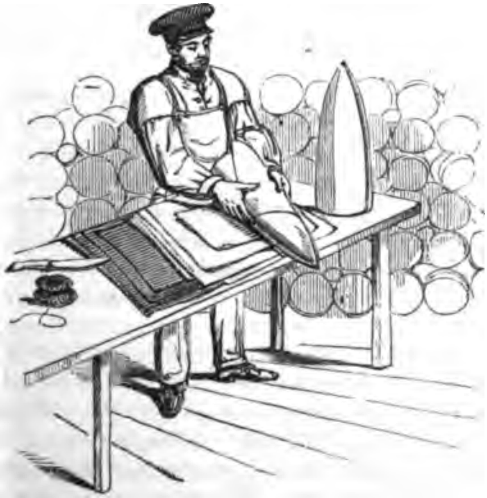
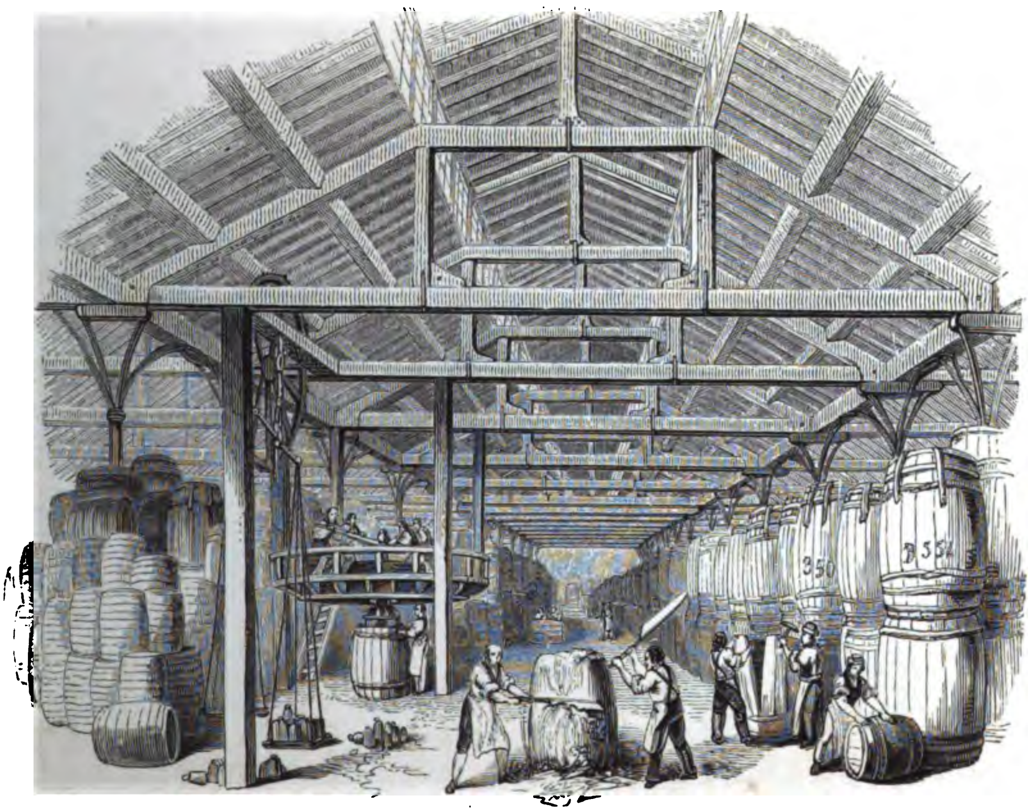


Fig. 7.

An extraordinary quantity of pipes and tubes of various sizes traverse the premises in every direction. Some convey water from the well to the reservoir on the top of the building; others re-convey it to cisterns and pans in different parts: some conduct steam from the large boilers at the east side of the premises to the 'blow-up cisterns,' to the pans, to the 'heaters,' to the ovens or stoving-rooms, and to other parts; while another series convey the sugar and syrup from vessel to vessel, in different stages of their progress.

Thus have we rapidly gone over the routine of processes by which brown sugar is refined, and presented in the state of white crystalline sugar. In considering the advantages which result from any improvements in machinery or manufacturing processes, the first consideration generally is, how far the manufacturer is benefited thereby. But it is by no means unimportant to carry our inquiries beyond this point, and see in what way the improvements influence the retail purchaser. With regard to the refining of sugar, it is found that this refining is as perfectly effected by one series of processes under the modern system, as by a double series formerly; and the effect to the public is shown thus, that, whatever be the price of brown sugar (and the fluctuations in this price involve political considerations which we do not wish to discuss in this place), the price of refined sugar is now only about twenty per cent. greater, whereas in former times it amounted to forty per cent. It is supposed that a saving of nearly a million and a half sterling per annum is effected in this country by these circumstances.

We may here briefly explain the mode of reducing sugar to the state called *sugar-candy*. The process is not conducted at sugar-refineries, but is nearly as follows:—When the cane-juice has been clarified and boiled, it is placed in old moulds, having their lower ends stopped with linen, and crossed at intervals with strings or small twigs, to retain the sugar as it crystallizes. The moulds are then deposited in a cool place; and in proportion as the syrup cools, crystals are formed. In about nine or ten days the moulds are carried to the stove and placed in pots, and a small aperture made, through which the syrup can drop slowly. When the syrup has drained off, and the crystals of sugar-candy are become dry, the moulds are taken from the stove and broken in pieces to disengage the sugar, which adheres strongly to the sides of the moulds. By previously tingeing the syrup with cochineal or some other colouring substance, the candy may be made to assume any desired hue. The arrangement of the utensils used in this process is generally somewhat as follows:—A stove is set apart, the entrance into which is on the ground-floor, as near as possible to the pans: the top is usually from ten to fourteen feet above the ground, and covered like the top or crown of an oven. Beams are fastened into the wall, at a distance of about twenty-six inches from each other, and sufficient to bear a very large weight; upon which strong planks are laid when wanted. The candy-pots are placed upon the planks, and remain there till the process is finished. The pots are usually made of thin copper, without feet, and are perforated round the lower part with numerous holes, the purpose of which is this:—a coarse white thread is drawn by a needle through a hole in one side of the pot, carried across to a similar hole in the other side, brought back again through a third hole; and so backwards and forwards till the lower part of the pot is traversed by several lines of thread; after which the holes are stopped. Each string forms a nucleus round which the candy crystallizes; an effect which used formerly to be produced by the use of small twigs.



VI.— Tobacco Warehouse.—London Docks.—Face p. 113.

VI.—A DAY AT A TOBACCO AND SNUFF FACTORY.

In entering next upon a rapid review of the processes by which tobacco, cigars, and snuff are produced, we feel that we must not indulge in many remarks on either the use or the abuse of this plant. There is certainly a strong temptation so to do, when we are told in 'Dr. Everard, his Discourse of the wonderful Effects and Operations of Tobacco,' that the use of this plant will stay hunger and thirst, cure the dropsy, ease diseases of the head, catarrhs, and headache, cure dimness of sight, deafness, redness of the face, toothache, ulcerated gums, swelling of the throat, diseases of the chest, stomach pains, surfeit, swooning, colic, diseases of the liver and of the spleen, sciatica, burns, wounds, scalds,—in short, effect cures of all sorts of complaints in all sorts of animals. On the other hand, we have King James the First's dictum that the use of tobacco is "a custom loathesome to the eye, hateful to the nose, harmfull to the braine, dangerous to the lungs, and in the black, stinking fume thereof nearest resembling the horrible Stygian smoke of the pit that is bottomless." Leaving these two authorities to balance each other, we must be content to treat the matter simply in a commercial and manufacturing character; previously quoting Mr. Porter's remark, that "Tobacco is, perhaps, an object of more general use than any other production of the vegetable kingdom; and if we consider that in no sense can it be classed among articles necessary for human subsistence, this fact is calculated to excite our surprise as well as interest. The love of tobacco is evidently an acquired taste; yet it is one so easily and universally acquired, that this weed forms a luxury which is enjoyed in common by the African negro, the unclothed and houseless wanderer of Australia, the hardy American Indian, the slothful Asiatic, and every class of people throughout the more polished countries of Europe."*

It has happened in the preceding pages that a notice of manufacturing processes did not involve the necessity for a description of the raw materials operated on. For instance, in an account of the operations conducted at a Brewery, there is no necessity for beginning with a detailed account of malt and hops, the substances from which the flavour and qualities of the brewed liquor are derived. But in treating of *tobacco* the same remark cannot apply; for it is the actual leaf of the plant which is consumed, and not a particular substance extracted from it. Moreover, the processes whereby the leaf is brought into a prepared state are partly performed at the American plantation whence it is derived; and these must be glanced at before the subsequent processes can be understood. Although, therefore, we have headed this as being one branch of manufacture, yet the details will carry us to different quarters, instead of being confined within the limits of one establishment.

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* "Tropical Agriculturist," p. 151.

The botanical name for the tobacco plant is *Nicotiana*, given to it in honour of Jean Nicot, Lord of Villemain, who was ambassador from France to Portugal about the time when the plant was first brought to Europe. It is supposed that he introduced it first into France, as Sir Walter Raleigh did into England. There are seven species of the Nicotiana, of which only one, the *Nicotiana Tabacum*, need be particularly described. There are two varieties of this species, both annual herbaceous plants, rising with strong erect stems to the height of from six to nine feet, their foliage being fine and handsome. When full grown the stalk near to the root frequently attains a size greater than an inch in diameter, and is surrounded by a hairy clammy substance of a greenish-yellow colour. The leaves, which are of a light green, grow alternately at intervals of two or three inches on the stalk: they are oblong and spear-shaped; those lowest on the stalk are about twenty inches long, and they decrease in size as they ascend, the top leaves being only ten inches long, and five broad. The young leaves, when about six inches long, are of a deep green colour, and rather smooth; but as they approach maturity, they assume a yellowish tint, and a rougher surface. The flowers grow in clusters from the extremities of the stalks: they are yellow externally, and of a delicate red within; the edges, when they are full-blown, rather inclining to purple. These flowers are succeeded by kidney-shaped capsules of a brown colour, each one of which contains about one thousand seeds, so that the whole produce of a plant has been sometimes estimated at three hundred and fifty thousand seeds.

Such is the appearance which the plant presents when under culture. In Virginia (the centre of the tobacco-growing districts) the kinds of soil chosen for the cultivation of the plant are the chocolate-coloured mountain-lands, and the light black soil in the coves of mountains, and the richest low grounds. The ground is prepared in two ways, one for the seed, the other for the transplanted sprouts. The seed is sown in nursery-beds, called *patches*, bordered by some plant which will arrest the progress of the ravaging fly; and is effected generally about March or April. In a month's time, the young sprouts being ready for transplanting, ground is prepared for their reception. Hillocks, about eighteen inches high, are raised in parallel lines, four feet apart in one direction, and three feet in another. The sprouts, being about five inches high, are carefully taken out of the ground without injury to their tender rootlets, and conveyed to the field in a basket. One person places a sprout upon every hillock; and others, who follow him, make a hole with the finger in the centre of each hillock, and deposit the tobacco-plant in an upright position, pressing the earth round the root with the hands. This is an operation of great delicacy, as the leaves are exceedingly tender at this time, and any injury sustained by them would endanger the safety of the plant.

Incessant attention is required to the young plants in weeding, earthing, stirring the soil about the roots, removing dead leaves, removing superfluous sprouts called suckers, defending the plants from grubs and worms, &c. When the plant has attained the height of about two feet, it is *topped*, that is, the upper part is cut or pinched off, leaving such a portion of the stem as contains from five to nine leaves.

When the plants are in a fit state for being cut (at which time the leaves have changed their colour to a yellowish-green, the substance of the leaf is thickened, and the web more prominent), the cutters, each of whom is furnished with a sharp strong knife, proceed regularly along the rows of plants, cutting only such as appear to be ripe, leaving the rest for future operations. This selection is necessary, because if the tobacco be cut before it is fully ripe, it will not assume a good colour, and will be liable to rot when packed in the hogsheads. The stalks are cut almost close to the ground; and such of them as are sufficiently thick are slit down the middle, in order to admit the more unobstructed access of air and the evaporation of natural moisture. The cut and divided stalks are then laid down in regular order on the ground, the extremities of the leaves all pointing in the same direction, that they may be more easily gathered. This gathering is effected after a short exposure to the sun.

The next part of the process is the *curing* of the tobacco, which is carried on in large barns, whose sides are left partially open to allow a free circulation of air; and the internal area of the building, including the roof, is occupied by horizontal poles stretching across the barn in a parallel direction, and four feet asunder. These poles are connected together by cross-pieces called 'tobacco-sticks,' upon which the leaves are hung in order to be cured. There are several stages of these poles and sticks, one above another, a perpendicular space of four feet being left between them. The plants are carried to the curing-house as soon as the leaves have lost so much of their rigidity and brittleness as to bear handling without breaking; and the operation of hanging them is then effected, by suspending the plants upon the sticks with the points of the leaves downwards, resting them either by the stalk of the lowest leaf, or by the slit which has been made in the stem. Each stick, after being loaded with plants placed four or five inches apart, is conveyed to the stage of poles to which it belongs; and the whole area of the barn becomes thus filled with the plants, no two touching each other.

The unassisted action of the atmosphere produces, in a general way, that effect for which this process is undergone; but it is sometimes necessary to have small smothered fires of rotten wood or bark in the barn, to counteract the effects of an unfavourable state of the weather. An exposure to the air for a period of about five weeks makes the leaves of tobacco elastic and tough, and slightly covered with a glossy kind of moisture. The tobacco is then said to be '*in case*,' and is taken down from the sticks, in order that the stalks may be separated from the leaves. The general plan is for a party of negroes—men, women, and children—to sit in a circle on the floor of the tobacco-house, and to pull the leaves from the stalks, handing the former to two men placed in the centre, who distribute them into separate heaps according to their qualities. The lower or ground leaves, being generally soiled and torn, are separated from the rest; while of those produced in the higher part of the stalk, some are inferior to others: the whole are therefore distributed into three heaps.

At this stage in the proceedings it is necessary to mention a difference in the form in which tobacco is imported from the plantations. Our manufacturers distinguish between 'strip' and 'leaf,' or 'strip-leaf' and 'hand-work,' the former of which is the technical name for tobacco from which the stem of the leaf has been taken away before the latter is packed in the hogshead; whereas 'hand-work' is the name — sufficiently unmeaning, as most readers will deem it—applied when the leaf is packed whole, stem and all. The stripping is effected by taking the leaf in one hand, and the extremity of its stem in the other, in such a manner as to tear them asunder in the direction of the fibre—a process requiring some degree of expertness: but whether the leaves are stripped or not, the subsequent processes are nearly the same. The leaves are tied up in small bundles by a bandage at their thicker end, a small leaf being employed for that purpose by twisting it round the others, and securing its end in a kind of knot. Each little bundle of those leaves from which the stalks have not been removed is called a *hand*, and is, at the end where it is tied, somewhat thicker than a man's thumb, the length being from one to two feet, according to the kind of leaf. The 'strip-leaf' presents a slightly different appearance. All the bundles are then thrown together in heaps on a wooden platform, where they undergo the process of '*sweating*,' which is in its nature a slight degree of fermentation.

Packing for shipment is the next operation. The tobacco is packed in hogsheads; and there are three reasons why it is desirable to compress it into as small a space as possible—the expense of freight is considerably lessened by lessening the bulk; the tobacco is rendered less liable to external change by the air being nearly expelled; and the reception of moisture, or of injury from without, is rendered less likely to occur. Mr. Porter states that instances have occurred where vessels have been stranded, and their cargoes of tobacco, although long covered by sea-water, have yet been found on examination to be only very partially damaged on the outside; the middle, from one or two inches inward, proving perfectly sound and dry. The casks are made thoroughly dry for the reception of the tobacco, which is then deposited in them, the little bundles or *hands* being ranged one by one parallel to each other across the hogshead, the points all in the same direction. The next course or layer is reversed, the points being in the opposite direction; and any small spaces that may occur are filled up with bundles of less size, so as to bring all to a level. When the hogshead is about one-quarter filled in this way, a powerful lever-press is applied to the surface of the tobacco, so as to reduce the thickness from about twelve inches to three. The lever is kept in its position for several hours, in order that the tobacco may become so completely consolidated that it will not spring up again when the pressure is removed. Fresh portions are then laid in the hogshead, and treated in a similar manner, until the whole space is filled with a dense and compact mass of tobacco-leaves. A hogshead, forty-eight inches in length, by thirty or thirty-two in diameter, will hold one thousand pounds weight of tobacco, when compressed in this way.

We have now seen our tobacco packed in hogsheads, and shall here take leave of the plantations. Mr. Tatham, in his 'Essay on the Cultivation of Tobacco,' details the mode of examination to which the hogsheads of tobacco used to be subjected before they were allowed to be shipped from Virginia; but as many changes have taken place in the tobacco-trade during the forty years which have elapsed since Mr. Tatham wrote, and as this mode of examination is in some respects similar to that which is at present acted on in the London Docks (of which we shall presently speak), any further notice respecting the proceedings previous to shipment may be dispensed with here. Referring to Mr. Porter's valuable volume, before quoted, for more minute details respecting the cultivation and curing of tobacco, we will suppose a cargo to have arrived at London, and will follow it in its subsequent career.

Among the wonders which are presented by the numerous docks at the east end of the town, few are so remarkable as the *Tobacco-Warehouses* at the London Docks. In Pennington Street, Ratcliffe Highway, is one of the entrances to these Docks, very near the tobacco-warehouses. The warehouses lie at the left hand of the entrance gates, and are entered through an archway. After going a few yards through a path bounded on either side by hogsheads of tobacco, we come to a vast area of ground whose appearance is indeed bewildering. Almost as far as the eye can reach, southward and eastward, are ranges, tiers, or alleys of hogsheads, whose number is immense. Passage after passage occurs, each several hundred feet in length, and only wide enough to admit the necessary traffic; all parallel one to another, and all bordered on both sides with close and compact masses of hogsheads, generally two in height. The whole are under one roof, or rather one succession of roofs. The mass of tobacco here stored is so great, that there have frequently been at one time more than *twenty thousand hogsheads*, averaging twelve hundred pounds of tobacco each.

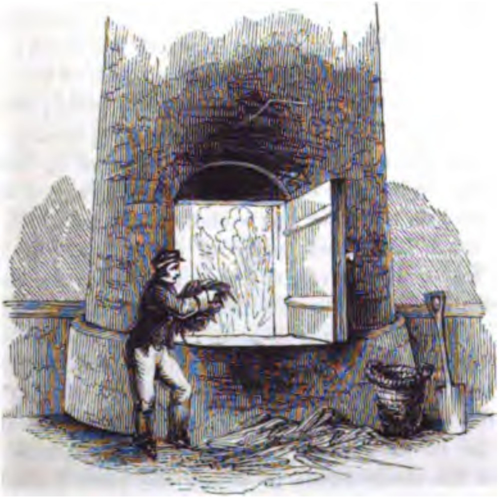
Those who are unacquainted with Customs and Excise regulations may perhaps not deem it immaterial to know why this enormous quantity of tobacco is kept in one place. The duty paid on every pound of tobacco is very large; but this duty is not demanded so long as the tobacco remains at the docks, or rather in the warehouses attached to the docks. As soon as it is landed at the docks from the ship and placed in the warehouses, it is considered to be "*in bond*," under the care of the State, and cannot be removed thence till the duty is paid. A small *rent* is paid during the time that it remains in the warehouses. Permission is given for the transference of samples from hand to hand, under certain regulations; but the bulk of the tobacco must remain until the somewhat inordinate demands of the state are satisfied.

Scarcely any other important article of consumption pays a duty so enormous, when compared with the cost price, as tobacco. The average value of the tobacco brought to England, including the profits of the cultivator, the ship-owner, and all parties concerned, is about sixpence per pound; but the duty paid on it is now *three shillings and twopence* per pound, being more than six times the full value of the article itself. We have heard of an instance, at a time when the duty was somewhat higher than it is now, of tobacco worth only twopence halfpenny per pound paying a duty of four shillings,—nineteen times the value of the commodity! The expediency or inexpediency of this impost, in a fiscal point of view, it is no part of our purpose to descant on here; but it is necessary to mention these matters in order to understand certain curious effects which result therefrom. If by any circumstance the whole or a portion of a hogshead of tobacco becomes injured, previous to its arrival at the docks, the owner would rather lose it altogether than pay the enormous duty on the damaged portion. Were the duty very small, it is possible that the damaged portion might be sold at a price which would more than cover the duty on it; but as it is, the duty is too high to permit of such a speculation. The State allows the damaged portion to be *burned*, without any duty having been paid on it; and we proceed to describe the arrangements whereby this is effected.

In various parts of the warehouses are large scales for weighing the hogsheads of tobacco, together with other apparatus connected with the examination of its quality. At each of these stations is a small temporary room or counting-house, for the accommodation of the supervising officer, under whose immediate inspection the examination proceeds. A hogshead of tobacco having been brought to one of these stations, the head of the hogshead is knocked out, some of the staves loosened, and by a dexterous management the hogshead is taken completely off the tobacco, leaving the latter standing upright as a brown-coloured mass of tobacco-leaves, very dense and impenetrable. As we before observed, such a mass, four feet high and less than three feet in diameter, weighs as much as a thousand pounds. By an examination of one end of this cylindrical mass, we can see the manner in which the little bunches of tobacco-leaves are ranged layer upon layer, and compressed very tightly together. The examination then proceeds, of which we can of course say very little in words, since it is only by long experience that the nature and extent of any damage which the tobacco may have received can be appreciated. Let us suppose, however, that a portion of the exterior has, through the action of sea-water, bad packing, or any other cause, become so damaged as to be not worth preservation. In such cases two men, provided with long cutting instruments, stand on opposite sides of the cylindrical mass of tobacco, and chop away all the injured part, by small bits at a time. The compression to which the tobacco has been subjected gives such a solidity and denseness to the mass, that very powerful blows are required to chip off the damaged surface, especially at the cylindrical parts, for there the cutting is effected crosswise to the direction of the stalk and leaf. When we visited the warehouses, we saw a mass of tobacco which was being cut away to the depth of eight inches on one side, so deep had the injury extended.

When the damaged portion is all cut away, the remainder is carefully weighed, in order that the amount of duty accruing to the State may be determined; and samples are then frequently taken from the hogshead, which suffice to effect a sale between the vendor and the buyer of the hogshead of tobacco. The opened and loosened cask is next slipped over the mass of tobacco, and fastened as closely to it as is necessary by the aid of the hoops, the head of the hogshead being also fixed at the same time. In the frontispiece to this subject we have represented some of the operations incident to the examination of the tobacco in the warehouses; the opening of a hogshead; the weighing by means of large scales; the cutting away of the damaged tobacco from the surface of the mass; and the pressure of the tobacco into the hogsheads again after examination, by a powerful screw-press worked by four men situated on a platform above. A walk through the warehouses at the London Docks brings us to many different spots where these operations are going on.

But what becomes of the damaged tobacco? Is it swept away, or sold as a perquisite? Neither. Damaged though it may be, it would still be worth a price sufficient to create a branch of trade, which, supposing no duty to be paid on the damaged tobacco, would lead to various plans injurious to the revenue. It is all burned within the walls of the warehouses. Not far from the north-east corner of the warehouse a door inscribed with the words 'To the kiln' points out the spot where this burning is effected. The kiln is a building of a form somewhat circular—so dark, that its interior arrangements can with difficulty be seen until the eyes are accustomed to the dusky light—and provided with a furnace and several troughs. Here the superintendent points out to the visitor the 'Queen's tobacco-pipe'—a jocular name applied to the chimney and the furnace in which the damaged tobacco is consumed. The tobacco is brought to the kiln, placed on the floor, and thence thrown into the furnace by an open door, and burned. As the smoke arising from this combustion is of a deleterious character, the chimney of the kiln is carried to a considerable height in order to convey the smoke to a sufficient distance for avoiding unwholesome effects. The greater part of the tobacco is thus



"Queen's Tobacco-pipe"—Tobacco-kiln.—Fig. 2.

consumed; but an ash remains, which is from time to time drawn out of the furnace, and thrown into the bins or troughs at the side. These ashes are by no means valueless: they are sold as manure, for which they possess good qualities, one ton of ashes being used to manure four acres of ground. The ashes also constitute a useful kind of tooth-powder.

Thus much for the operations which the tobacco undergoes before it comes into the hands of those who are termed "snuff and tobacco manufacturers." It will be seen by these details why it is that a notice of the processes carried on in any one establishment would necessarily fail in conveying an accurate idea of the routine by which the simple plant is brought into a state fit for use. The tobacco is in fact half-manufactured before it leaves the warehouses.

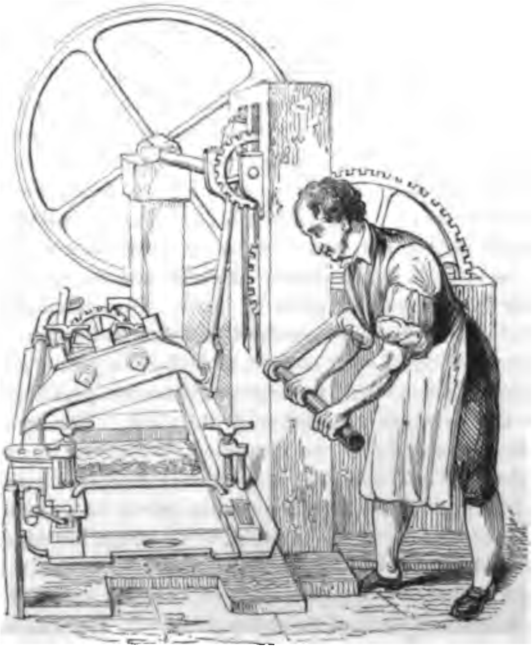
The leaf being brought to the manufacturer in hogsheads, he proceeds to give it one of the three forms in which it is used, *i. e.* tobacco, cigars, and snuff. Most persons are probably aware of the main points of difference between these three forms of the plant; but as all are not so, we may shortly state that common smoking *tobacco* is the leaf, generally divested of the stalk, and also generally cut up into shreds or filaments; *cigars* are bundles of the tobacco-leaf, divested of the stalk, and wrapped up into the close and well-known form which those articles present; *snuff* is formed partly of the stalks of the leaves, and partly of the leaves themselves, cut and ground into the state of powder. These are the distinctive qualities in which the three *commercial* forms of the plant differ one from another; but each one of the three has many varieties, arising partly from differences in the quality of the original leaf, partly from the manner in which the leaf is cut, and partly from the processes preparatory or subsequent to the cutting. It may likewise be here remarked that the manufacture of the leaf and stalk into the three forms in which the plant is used generally devolves upon three classes of persons. The same man who makes cigars does not generally prepare the tobacco which is smoked in pipes, while the grinding of snuff is a different occupation from either. The processes, too, are conducted in a somewhat different manner in different houses. We shall therefore state in a simple form the general nature of the processes, as carried on in London.

A hogshead of tobacco being opened, and ready for preparation, the plant is dug out piecemeal by the aid of an iron instrument. The bundles of leaves are, as we before observed, compressed so powerfully together, that they become almost one mass; and indeed without the aid of moisture it would be almost impossible to separate them. The heaps or pieces are sprinkled with water, a process technically termed 'liquoring,' by which the bunches of leaves may be separated one from another. If the tobacco is in the form called 'strip-leaf,' in which the stalk has been removed before the leaves were packed in the hogshead, each separate leaf or half-leaf becomes loosened from the others by the operation of liquoring; but if it be 'hand-work,' *i. e.* retaining the stalks, and bound up in bundles called 'hands,' the liquoring in the first place loosens the bundles one from another; and these being untied, the leaves themselves are separated.

The 'hand-work' must become 'strip-leaf' before the tobacco is in a fit state for use; or, in other words, the stalk must be taken out, either at the plantations where the plant is grown, or in England after importation. The stripping or taking off of the stalk is effected generally by women or boys. The leaf is folded along the middle, and by means of a small instrument, and a dexterous manœuvre acquired only by practice, the stalk is stripped from the leaf, and laid on one side,—the leaf being laid in another place by itself. One particular kind of tobacco, however, known to consumers by the fanciful name of 'bird's-eye,' contains a portion of stalk as well as leaf. To produce this form of the 'Virginian weed,' the various processes are performed on the leaf without the previous extraction of the stalk. The action of the cutting-machine, presently to be described, produces a large number of round, light, and exceedingly thin sections or slices of stalk, which become mixed up with the fine thread-like fibres into which the leaf itself is cut, and thus produce an appearance which has given rise to the name of this particular form of the plant. Let not the reader, curious in the philosophy of tobacco, hope, however, to meet with the brilliance of a bird's eye in these slices of stalk. He will meet with no such thing. The workers in polished woods have also appropriated this simile, by giving the name of 'bird's-eye maple' to a spotted variety of that wood. The birds have no reason to be proud of the compliment in either case.

The cutting of the leaves into those fine shreds which form the greater part of smoking tobacco is not effected leaf by leaf; but a large number of leaves are pressed together in the form of a cake, and then cut. The leaves, after having been separated one from another, and stripped of their stalks, are moistened to a certain degree, either by sprinkling or by immersion in a liquid prepared for that purpose. This process not only gives to the leaves a degree of moisture which enables them to cake well together, but also has an influence on their subsequent flavour, and is therefore of considerable importance in the manufacture.

The cutting-machine by which the thread-like fibres are produced is represented in Fig. 3, and the mode by which the tobacco is brought into a form fit for placing in the machine is as follows:—On one side of the tobacco manufactory is a powerful press, or a series of presses, capable of operating on a surface fourteen or sixteen inches square. The leaves are taken up out of a trough, in a damp state, and laid in a 'mortar-press,' layer after layer being piled up to a certain height. The whole are then subjected to pressure, by means of an iron plate which descends into the press upon the tobacco, and is con-



Tobacco-shredding Machine.—Fig. 3.

nected above with the screw of the press. The tobacco is then removed from the 'mortar-press' to the 'standing-press,' where it is pressed into a mass one-third of the thickness which it originally presented. The mass of leaves is allowed to remain in the press several hours, in order that it may not spring up or loosen when the pressure is removed.

The cake, pressed as hard as a board, but clammy and wet from the previous sprinkling of the leaves, is then laid on the bed of the cutting-engine, in order to be cut into shreds. These engines, like most other engines used in manufactures, have undergone considerable changes as improvements became introduced. Originally tobacco used to be cut by means of a long knife worked by hand. After a time, a hand-engine was used, in which the workman had nothing to do but to turn a winch-handle, the arrangement of the machine serving both to cut the tobacco and to shift the cake along as it became cut. Then horses were used to turn the machine, instead of applying human labour. Lastly, the power of steam was applied, by which the whole work was brought within the scope of this moving-power; the attendance of men being required only to place the cake in the engine, to attend it while at work, and to remove the tobacco when cut.

But the hand-engine, the horse-engine, and the steam cutting-engine, however different in their moving-power, all cut the tobacco nearly in the same manner. The cake is laid on an iron bed, which is susceptible of a slow progressive motion by means of a screw passing beneath it. This screw is connected at one end with a cog-wheel, in such a manner that, while the machine is working, the bed on which the tobacco is laid is urged slowly forward. Another part of the mechanism gives motion to a sharp blade, rather longer than the width of the cake. This knife or blade has a reciprocating vertical motion, or rather a motion somewhat similar to that of a pair of nut-crackers, inasmuch as there is a hinge or fulcrum at one end.

The cake being placed on the bed of the engine, confined in a kind of case or box, the motive power is applied, and the process of cutting is immediately commenced. The cake is about two inches thick, and each action of the cutting-blade slices off a thin film from one end of the cake. As the cake itself is composed of a very large number of separate leaves of tobacco, it follows that each film or shaving taken from the edge, generally at right angles to the surface of the leaves, must be formed of separate pieces, in no case larger than filaments or fibres. The thickness of these fibres is regulated in a very ingenious manner. Immediately after the blade or knife has made one cut, the cake is moved forward a minute distance, so that the next following cut of the blade may be distant some small space from the former. It depends upon the number of cogs in the wheel at the end of the underlying screw, whether this distance, and consequently the diameter of the fibres of tobacco, shall be greater or smaller. For one kind of tobacco the cog-wheel contains about thirty cogs, for another about thirty-six; and these produce fibres whose diameters differ in the ratio of thirty-six to thirty, or six to five. To explain minutely how this difference is brought about is no easy matter. Those who are acquainted with the action of wheel-work will readily understand the nature of this effect; while those who are not could scarcely understand it from mere description.

When the cake is entirely cut up into shreds, or when, as it is technically termed, the 'box is out,' the engine is stopped, and the cut tobacco, in a clotted and damp state, is taken up and put into a trough or case. A new cake is then adjusted to the bed of the engine, and the operations proceed as before. In the principal factories the cutting-machines are worked by steam-agency; but our cut represents one of the hand-engines, worked by means of a winch: the principle of the cutting part is the same as in the other, and more easily understood when divested of the mechanism connected with the steam-engine.

The various kinds of tobacco ordinarily used for smoking owe their different qualities to many different circumstances; some depending on the kind of leaf, some on the colour of the leaf, some on the retention of the stalk, some on the extent to which the leaf is 'liquored,' and some on the relative fineness of the fibres into which it is cut. 'Bird's-eye' is, as we have before stated, produced by cutting up the stalk together with the leaf, a plan which is, we believe, never adopted with any other form of tobacco. That kind of tobacco which is called 'returns' is made of the lightest-coloured leaf selected from the hogshead; and this light colour is preserved by caution in the subsequent arrangements. A considerable quantity of water in the process of 'liquoring' has a tendency to darken the colour of the leaf, as has likewise an excessive amount of pressure when in the form of a cake; by using a small amount both of moisture and of pressure, therefore, lightness of the colour of 'returns' is preserved. The very strong kind of tobacco called 'shag,' which is used both for chewing and smoking, owes its quality to different circumstances, the first of which is the choice of the darkest-coloured leaves in the hogshead; and in the subsequent processes the tobacco is well 'liquored,' and screwed down in the press with great force. This kind of tobacco is subdivided into two sorts, 'fine' and 'common,' the chief difference between which is in the diameter of the fibres into which the leaves are cut, the 'fine' being cut by the engine when the bed is pushed forward by a wheel having more cogs than for cutting the 'common' kind.

Many of the names by which tobacco is known were given from the names of the places whence it was brought, and from other circumstances having but little reference to the quality of the tobacco. 'Oronoko,' a name given to one kind of tobacco, was probably derived from the South American river of that name. 'Kanaster' or 'Canaster' was originally the name given in America to baskets of rushes or cane, in which they put the tobacco sent to Europe; and hence the designation of 'Kanaster tobacco' was given to the leaves imported in those baskets. At present the two kinds known by these respective names are manufactured from the best leaf, generally from Havannah. Oronoko is cut finely, somewhat similar to fine 'shag,' but Kanaster is much coarser. This forms the chief difference between the two kinds, the quality and preparation of the leaves being in other respects about equal.

These are the principal forms of tobacco calculated to be smoked in pipes; a mode of using which gave rise to the following lines, in the "Marrow of Compliment," a work published in 1654:—

"Much meat doth Gluttony procure,
To feed men fat as swine;
But he 's a frugal man indeed
That on a leaf can dine.

"He needs no napkin for his hands,
His fingers' ends to wipe,
That hath his kitchen in a box,
His roast-meat in a pipe."

We must not omit to mention a kind of tobacco which glories in the name of 'pig-tail,' and which perhaps is about equally well named with 'bird's-eye.' Pig-tail tobacco is a rope or cord, about equal in diameter to the thicker end of a common tobacco-pipe, and of as great a length as the manufacturer may choose to make it. The manufacture of this article requires the simultaneous aid of a man and two boys. The bench employed is several yards in length, and at one end of it is a kind of spinning-wheel, which is kept in rotation by one of the boys. The other boy has spread out before him a supply of leaves, deprived of the stalks and in a damp state. He opens the leaves one by one, and lays them down on the bench, end to end. The man follows him, and rolls up these successive leaves into the form of a cord, by a very peculiar motion of both his hands. The length of 'tail' which happens to have been made at any one moment is kept constantly rotating by the action of the wheel; and the man, adding leaf after leaf to it with the left hand, presses and rolls it by means of a palm of leather or wood held in his right. The manœuvre is so quick and so dexterous, that a spectator can hardly see where or how the leaf becomes absorbed into the 'tail,' and made part of its substance: it is one of those operations of which manufactures present such numerous examples, in which considerable skill and 'knack' are required for an apparently simple operation. As the tobacco is spun, it becomes wound off at the same time on a frame connected with the spinning-wheel. The pigtail is afterwards wound or twisted up into a hard, close ball, and has a black colour given to it by steeping in tobacco-water.

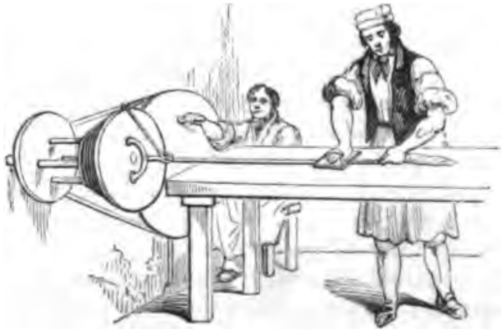


Fig. 4.

Of all the various ways in which tobacco is used in England, none has made a more striking advance within the last few years than *cigars*. However much this form of the plant may be used in Spain and in the tropical regions of America, it was till a few years ago scarcely known in England, except to the higher class of smokers; but now every stripling who is just shooting up into manhood thinks a cigar indispensable, as a symbol whereby the world may know that he has at length become a man; and lest this important piece of information should not be diffused widely enough by his remaining within doors, he exercises his new vocation in the open street.

The process of cigar-making is pretty nearly the same, wherever carried on. In Figs. 5 and 6 we have represented a boy prepar-

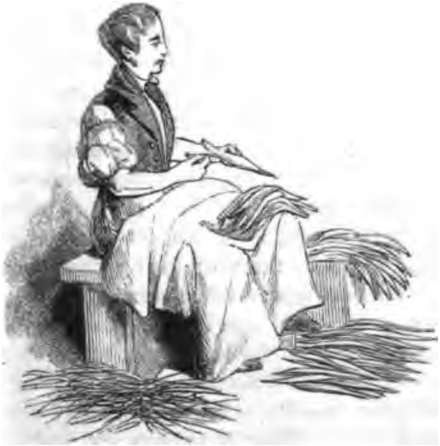


Fig. 5.

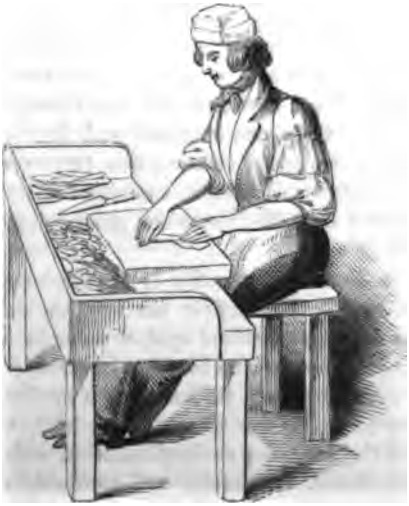


Fig. 6.

ing the leaves for the cigar-maker, and a man making the cigars. The unstripped leaves, *i.e.* the leaves from which the stalks have not yet been removed, are placed in front of the first-mentioned workman; he takes up the leaves one by one, folds them, strips off the stalk by a quick and dexterous movement, throws the stalks on his right hand, and lays the stripped leaves smoothly on his left. He is on the left side of the cigar-maker, to whom he hands up the leaves as fast as they are wanted.

The cigar-maker is seated on a low stool in front of a low work-bench, provided with raised legs on three of its sides, but open at the side next the workman. He takes a leaf of tobacco, spreads it out smoothly before him on the bench, and cuts it to a form somewhat like that of one of the gores or stripes of a balloon. He then takes up a few fragments of tobacco-leaf, consisting of various small cuttings, lays them on the spread leaf, and rolls them up into a form nearly resembling that of a cigar. He next places this cigar against a gauge or guide, formed of a piece of iron, and cuts it to a given length. Finally, he lays a narrow strip of leaf on the bench, and rolls the cigar spirally in it, twisting one end to prevent the leaf from becoming loosened. All this is done with great rapidity, a few seconds only being required for the making of one cigar. When the cigars are made, they are dried in different ways, according to the time when they are wanted for sale. The rate of duty on foreign cigars, as well as on all kinds of tobacco manufactured abroad, is so enormous (nine shillings per pound—probably sixteen or eighteen times the real value of the leaf itself), that the quantity imported from abroad is very small compared with that of tobacco in the leaf. Only one hundred and fifty thousand pounds weight were entered for home consumption two or three years ago, although the unmanufactured tobacco amounted to sixteen millions of pounds. This rate of duty has, therefore, given rise to an extensive home manufacture of cigars.

We have next to direct our attention to the third form in which the plant is used, viz. *snuff.* This article has been the theme of as many grave accusations as those directed against tobacco in the form for smoking; but the grave accusations have been as fruitless in the one case as the other. Some have treated the matter in a medical point of view; others in reference to the welfare of the purse; while a Lord Stanhope, of past times, made the following curious statistical estimate of the subject:—"Every professed, inveterate, and incurable snuff-taker, at a moderate computation, takes one pinch in ten minutes. Every pinch, with the agreeable ceremony of blowing and wiping the nose, and other incidental circumstances, consumes a minute and a half. One minute and a half out of every ten, allowing sixteen hours to a snuff-taking day, amounts to two hours and twenty-four minutes out of every natural day, or one day out of every ten. One day out of every ten amounts to thirty-six days and a half in a year. Hence, if we suppose the practice to be persisted in for forty years, two entire years of the snuff-taker's life will be dedicated to tickling his nose, and two more to blowing it. The expense of snuff, snuff-boxes, and handkerchiefs will be the subject of a second essay, in which it will appear that this luxury encroaches as much on the income of the snuff-taker as it does on his time; and that by a proper application of the time and money thus lost to the public, a fund might be constituted for the discharge of the National Debt." Without entering upon this "second essay," or upon the patriotic plan alluded to in the last sentence, we proceed to the only part of the subject to which this paper relates, viz. the commercial and manufacturing arrangements by which these luxuries are produced.

Snuff is made from stalks alone, from leaf alone, or from leaf mixed with stalk,—circumstances which render the whole of the imported leaf valuable. In every case a greater amount of care is required in the preparation of snuff than of tobacco. The various qualities of snuff are due to a great variety of circumstances, principally under the control of the manufacturer. The purest kind, known by the name of 'Scotch,' is either made entirely of stalks, or of stalks mixed with a small proportion of leaf; and in either case there is very little 'liquoring' applied to the tobacco, as that would darken the colour of the snuff. There are many kinds of snuff called 'high-dried,' such as 'Welsh' and 'Lundyfoot' (the latter being named after a celebrated maker). These owe their qualities chiefly to the circumstance that they are dried so much as to acquire a slight flavour of scorching.

The snuffs called 'rappee,' of which there are two kinds, 'brown' and 'black,' are made chiefly from leaf, mixed with the 'smalls,' or broken fibres of tobacco, that are too small to be smoked conveniently in a pipe. The dark colour is principally produced by wetting the powdered tobacco in a bin or box, and allowing it to remain for a considerable time, turned occasionally with a shovel; during which time it undergoes a slight degree of fermentation, whereby the colour is darkened.

The original quality of the leaf is as much attended to as the manufacturing processes. 'Scotch snuff' is made principally from the stalks of light dry leaves; whereas 'rappee' and the darker snuffs are made from the darker and ranker leaves. A process of *scenting*, too, has great influence on the flavour of the snuff, since the manufacturer can introduce any kind of scent which he thinks may please his customers. Thus, 'Prince's mixture,' among the low-priced snuffs, and the interminable varieties of 'fancy snuffs,' owe no small part of their flavour to the kinds of scent introduced. Other kinds, however, such as 'high-dried,' 'Welsh,' 'Lundyfoot,' &c., are chiefly dependent on the peculiar circumstances under which they are dried. In relation to the last-named snuff, Mr. Barlow states—"The celebrated Lundyfoot snuff derives its particular flavour chiefly from having the fermentation carried to a very high pitch before the batch is turned; and it is said that its first discovery was owing to the neglect of the man attending upon the batches, and who, by getting drunk, made his master's fortune. Another story also prevails with respect to the discovery of this snuff, so much esteemed by inveterate snuff-takers, which attributes it to an accidental fire, which, by scorching some hogsheads of tobacco, gave them a peculiar flavour when manufactured. This story is, however, evidently without foundation, as the snuff manufactured by Lundyfoot still continues to retain a peculiar flavour which cannot be imitated by other manufacturers; a circumstance which is not likely to continue if the effect simply depended upon the degree of drying."

It is a curious circumstance, and one little suspected by those who are in the habit of using snuff, that almost the whole of that article which is sold in the metropolis, either wholesale or retail, is ground in or near the town of Mitcham, in Surrey, owing to the excellent water-power afforded by the river Wandle, in flowing through the town. Many manufactories on the Wandle derive their mechanical power from water-wheels, which were almost invaluable before the use of steam became prevalent. The advantage of employing a particular class of persons for grinding snuffs, instead of each manufacturer grinding his own, is easily understood. Few manufacturers dispose of enough snuff to keep a grinding-mill constantly employed; and under such circumstances it is generally cheaper to obtain the aid of another person whose premises and arrangements are devoted wholly to that occupation. Such is the case with regard to the snuff-mills on the Wandle. There are several of these establishments to which the London manufacturers send their snuff in a certain stage of preparation.

The mills are provided with two different kinds of grinding-machines, such as are represented on a small scale in Fig. 7. In one of them a pair of cylindrical stones, several feet in diameter and a foot or more in thickness, are set up on edge on a slab or bed beneath, and have then a twofold motion given to them, resembling that of the wheel of a carriage which is going round in a small circle. By means of a horizontal axis passing through the centre of the stones, the stones wheel along the surface of the bed; and by giving to the axis itself a motion round another but vertical axis, the stones are carried round in a small circle. The snuff to be ground is laid on the bed or support, and the broad edge of the heavy stone passes repeatedly over it, by which the particles are reduced to powder.

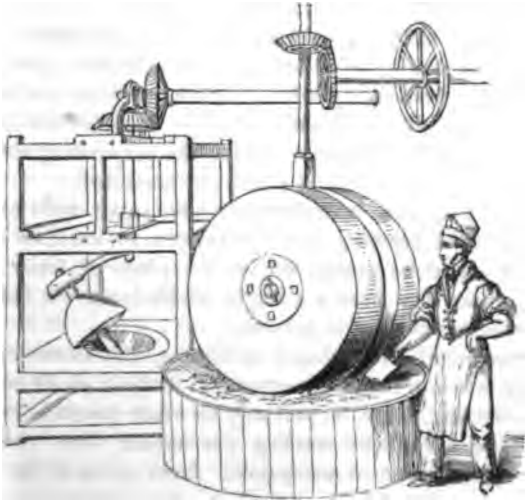


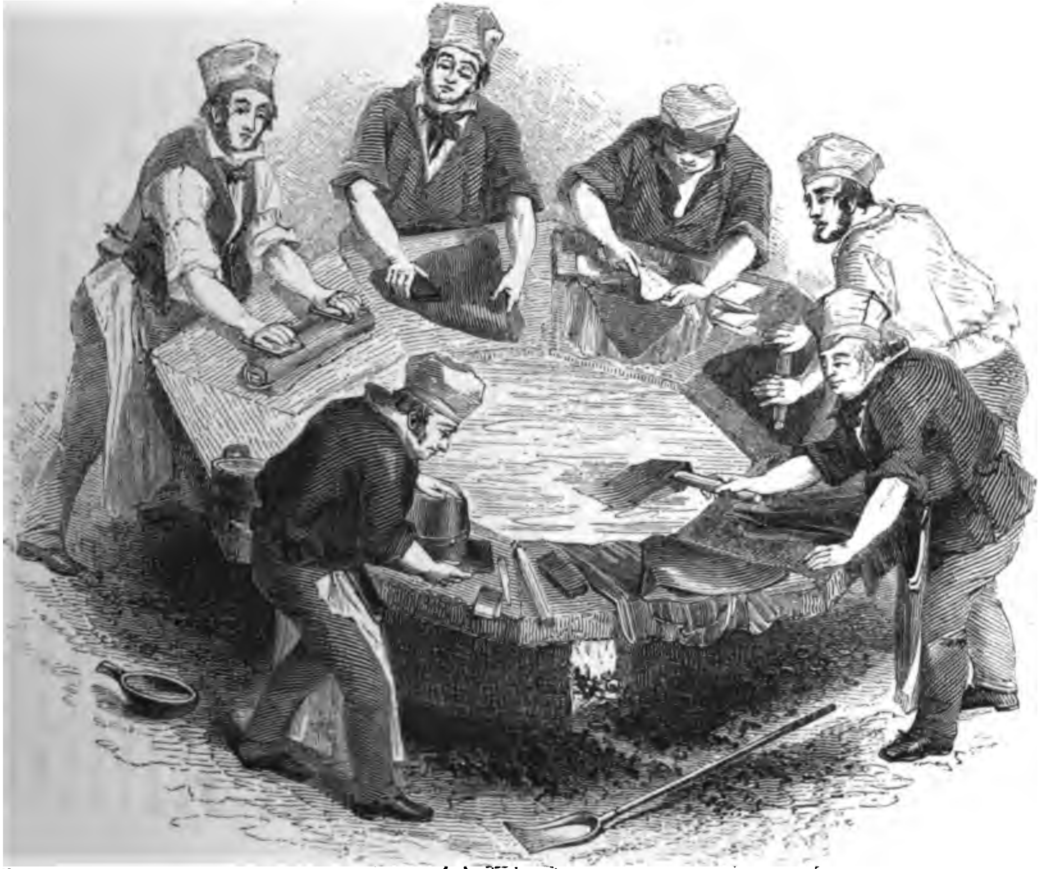
Fig. 7.

In the other form of grinding-mill, the snuff is put into a kind of cell or mortar, in which it is ground by a pestle moved in a singular manner. The pestle is connected with a set of jointed arms or levers, so adjusted one to another as to give to the pestle a motion best calculated to effect the grinding of the snuff. Every establishment for grinding snuff contains a considerable number of both these machines; since some kinds of snuff are best ground by the one, and others by the other.

Beyond the grinding, and a preparatory drying, nothing is done to the snuff at the snuff-mills. The proprietor brings it to a certain stage of preparation before it is sent to the mill, and in most cases passes it through some finishing operations after it is brought from the mill. The high-dried snuffs, such as Lundyfoot, Welsh, Scotch, &c., are sometimes made from stalks, which, before grinding, are cut into fine shreds; but very often the entire stalk is dried so intensely that it may easily be ground to powder without the preparatory shredding. In such case the lightest and finest stalks are presented.

Many of the London manufacturers have small mills on their own establishments, for grinding small quantities of snuff, or for passing through any particular process the various kinds of fancy snuffs; but we are not aware that there is a single establishment in London where the main bulk of the snuff is ground.

The Excise regulations relating to tobacco, which were formerly very burdensome, are now much less vexatious. Indeed, so far as regards the mode of collecting, there is probably no other instance in which the revenue of three millions sterling per annum from one article is obtained with less personal annoyance. Here is one of the old laws by which the operations of the manufacturer used to be controlled:—"Every manufacturer shall give notice in writing to the officers (if in London six, in cities and market-towns twelve, and elsewhere twenty-four hours) before he shall begin to strip, spin, or press any tobacco for cutting; or make any tobacco into carrots, or flatten any stalks for Spanish; and shall express therein the weight of each article, and the time he intends to begin. And the officer shall attend accordingly, and he shall begin within one hour of the time so mentioned, and shall proceed without delay." These embarrassing regulations are no longer rigidly acted on; although similar plans still disgrace the modes of collecting the duty in the glass-manufacture, the soap-manufacture, and many others. And indeed, since the period of the "visit" to which this article relates, the tobacco-laws have been again made stringent, owing, as it is said, to improper practices on the part of some of the manufacturers.



VII.—The Hat-Battery, or 'Kettle,' with Men employed in Wetting, Rolling, Pressing, 'Ruffing,' and Blocking the Hat-Bodies.—Face p. 137.

VII.—A DAY AT A HAT-FACTORY.

The early history of our manufactures frequently excites a smile at the quaint and energetic manner in which some of the old writers denounce the fashions of their times; but while we are often disposed to agree with them in ridiculing the strange forms of dress which have been adopted at different periods, we must withhold our assent to the principles of their commercial economy, which are often lamentably short-sighted.

Philip Stubbs, a writer of the Elizabethan age, published, in 1585, his 'Anatomie of Abuses,' in which, among other things, the costume of the time is made the subject of censure. After anatomizing ladies' dresses, and discoursing on the iniquities of ruffs and furbelows, he visits the wardrobes of the other sex for a similar purpose, and thus speaks of the then fashionable hats:—"Sometimes they use them sharp on the crown, peaking up like the spear or shaft of a steeple, standing a quarter of a yard above the crown of their heads, some more, some less, as please the fancies of their inconstant minds. Some others are flat and broad on the crown, like the battlements of a house. Another sort have round crowns, sometimes with one kind of band, sometimes with another, now black, now white, now russet, now red, now green, now yellow; now this, now that, never content with one colour or fashion two days to an end. And thus in vanity they spend the Lord's treasure, consuming their golden years and silver days in wickedness and sin." But the material pleases him as little as the form and colour:—"And as the fashions be rare and strange, so is the stuff whereof their hats be made divers also; for some are of silk, some of velvet, some of taffetie, some of sarcenet, some of wool; and, which is more curious, some of a certain kind of fine hair. These they call *Bever Hats*, of twenty, thirty, or forty shillings price, fetched from beyond the seas, from whence a great sort of other vanities do come beside."

What would be the surprise of Philip Stubbs if he could now witness the extent to which the "vanity" of "Bever Hats" influences the commercial arrangements of England;—the importation of beaver and musquash furs from North America, of neutria furs from South America, of wools from various parts of Continental Europe, of gums, resins, and dyes from almost every part of the globe! If he found, too, that one single firm gives employment to fifteen hundred persons in making hats of various kinds, and that the value of all the hats made in Great Britain in one year is probably not much less than three millions sterling, he would perhaps cease to include "bever hats" in his list of abuses.

It will serve to mark the advance made in this respect, since the time of Stubbs, if we glance through a vast hat-factory now existing in Bermondsey, and reputed to be the largest in the world. This establishment, the property of Messrs. Christy, occupies two extensive ranges of buildings on opposite sides of Bermondsey Street, Southwark. These we will term the east and west ranges, each of which is approached by a gateway leading from the street. On entering the gateway to the east range, the first object seen at the end of a long avenue is a lofty chimney connected with a steam-engine, and rising to the height of one hundred and sixty feet. Over the gateway is a range of warehouses for wool and other articles; and from thence, proceeding onwards, is seen on the left a pile of buildings, occupied by cloth cap makers, hat-trimmers, and packers. On the right of the same avenue is another range of buildings, consisting of a fire-proof varnish store-room, silk-hat workshops, and shops wherein the early stages of beaver hatting are carried on. At the left of the great chimney is a building wherein common black-glazed or japanned hats are made; and near it is an archway leading northward to another avenue surrounded by buildings. These consist of a turner's shop, where blocks for shaping hats are made; a shell-lac store, where the lac is bruised, ground, and prepared for use; a blacksmith's shop, for the repair of iron-work used in various parts of the factory; a saw-mill and sawing-room, where machine-worked saws cut up timbers into boards for packing-cases required in the export department; a logwood warehouse, wherein a powerful machine cuts the logs into fine shreds; a fur-room, in which the beaver and other furs are cut from the skins by machinery; rooms wherein the coarse hairs are pulled from the skins; the steam-engine with its boiler, furnace, &c.; a carding-room, for disentangling the locks and fibres of wool; a blowing-room, for separating two qualities of beaver-fur, or hair; together with various warehouses, store-rooms, carpenter's shops, timber yard, &c. This brings us to the northern extremity of the range; on returning from which we pass wool-warehouses and sorting rooms, wool and fur washing-houses, stoving-rooms, fur-hat workshops, 'picking' rooms, clerks' offices, &c.

Crossing Bermondsey Street to the western range, we find a 'beaver store-room,' the dye-house, stoving-rooms, shaping and finishing rooms, &c.; the whole being, however, much less extensive than the east range.

It may excite surprise to hear of saw-mills, and blacksmiths', turners', and carpenters' shops, on the premises of a hat-maker; but this is only one among many instances which might be adduced, in the economy of English manufactures, of centralization, combined with division of labour, within the walls of one factory.

The nature of the operations carried on in the greater number of these buildings will perhaps be best explained by tracing the history of a beaver hat from the time when the crude materials enter the factory, till the hat, in a finished state, is warehoused.

If a dozen individuals to whom the subject is new were asked "How is a beaver hat made?" it is not improbable that we should receive a dozen different answers. One would think it is cast in a mould; another that the beaver's fur, skin and all, is stiffened and shaped; a third, that the fur is in some way woven into a kind of cloth, and put on a stiff foundation; but perhaps not one would have an idea of the beautiful process of *felting*, which is the groundwork of the whole theory of hat-making. A beaver hat consists mainly of two parts,—the *body* and the *covering*; the former of which is made of fine wool and coarse fur, mixed, felted, stiffened, and shaped; and the latter of beaver fur, made to adhere to the body by the process of felting. Wool and fur constitute therefore the main ingredients employed. For hats of inferior quality, coarse wool is employed for the body, and coarser fur, or sometimes fine wool, for the covering.

The wool is brought to the factory in a dirty and greasy state, retaining much of the moisture derived from the animal whence it was sheared. It is carried to a large washing-house, on a level with the ground, where the steam rising from immense boilers and tubs indicates the great scale on which the process is conducted. The wool is soaked and washed until the greasiness is removed, and is then subjected to the action of a screw-press, whereby all the water is expelled and the wool left in a clean state. From the washing-house the wool is conveyed to a drying-room; and when required for use, it undergoes the process of *carding* in the carding-room. This carding is analogous to one of the early operations in the cotton manufacture:—a machine worked by the same steam-engine which sets so many other parts of the working apparatus in motion, combs out the fibres of wool, and presents them in a light and tolerably disentangled state. The wool is then ready for the hatter; and we will trace the preparation of the fur up to the same point.

The term *fur*, in a general sense, refers to the hairy coating of such animals as the beaver, bear, marten, minx, hare, and rabbit. The skins of these animals, when merely dried after being stripped from the body, are called *peltry;* when the skin of the inner side has been converted into a sort of leather, by a peculiar process of tanning, the skins obtain the name of *furs*, in a restricted sense; and the term is still more restricted when applied to the hairy coating cut from the skin, and presented in the form of delicate filaments.

Now it is in the last-named form that fur is useful to the hatter; and the furs to which he gives the preference are those of the beaver, the musquash, the neutria, the hare, and the rabbit, of which the first is by far the most valuable. The beaver inhabits the districts of North-West America, where its peculiar habits of life have given rise to many marvellous tales, the truth of which is now more than doubted. The romantic details often presented in the lives of beaver-hunters, as well as the mode of dealing between them and the fur-dealers, have formed the subjects of many interesting narratives, with which the reader may be more or less familiar. The skins, as received at the factory, from the Hudson's Bay Company, are tolerably flat and stiff, measuring, generally, about three feet by two. The hairy surface is of a brownish colour, but is not that to which the hatter attaches value; for this animal has two kinds of hair on his skin, the innermost of which is short, implicated, and as fine as down, and the outermost thicker, longer, and more sparing. Of the separation of these two kinds we shall speak presently.

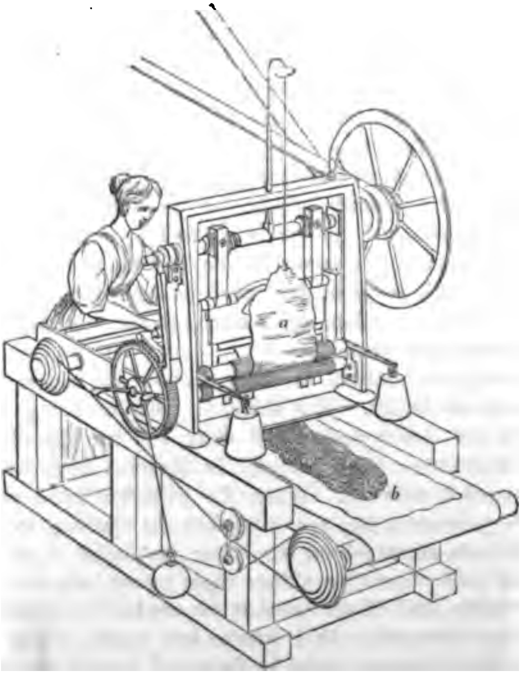
Neutria is the fur of a small animal called the *coypou*, the *quoiya*, or the *Myopotamus Bonariensis*, found in various parts of South America. The long or coarse hairs are generally of a reddish colour; and the inner or soft hairs brownish ash colour. It was not until about thirty years ago that hatters, influenced by the high price of beaver fur (which within a century has risen from 20*s*. to 80*s*. per pound), began to use neutria fur; but since that time the employment of them has become so extensive, that one million neutria skins have sometimes been imported in one year. This animal is yet little known to naturalists, but certain peculiarities in the skin beneath the fur have led to much conjecture among those who have frequent opportunities of inspecting the skins, concerning the structure and habits of the animal.

The *Musquash*, or *Mus Zibethicus*, is a North American animal, about the size of the common rabbit, and covered, like the beaver and the coypou, with two kinds of hair or fur, having different degrees of fineness. The name *musk rat* is sometimes given to this animal, on account of its secretion of a peculiar fluid having the odour of musk.

The fur of *hares* and *rabbits* is so well known as to render few words of description necessary. The rabbits fed on the wolds of Yorkshire are said to yield fur much exceeding in value that of the rabbits bred near London, by reason of the superior length and strength of the hairy filaments.

We have digressed a little in order to show the nature of the furs employed by the hatter. The skins, or pelts, on being conveyed to the factory, are rather greasy and dirty, and are therefore cleansed with soap and water: this is effected in the same large washing-house where the wool is cleansed. When the pelts are dried and required for further processes, they are carried to the 'pulling-room,' where a number of women, seated on stools, are employed in pulling out the coarse outer hairs from the skins: these coarse hairs are utterly useless to the hatter, and, if preserved at all, are sold for stuffing cushions and such-like purposes. Each woman lays a pelt on her lap, or on a low bench, and, by means of a knife acting against the thumb, tears out the larger hairs; her fingers and thumb being guarded by a stout leather shield.

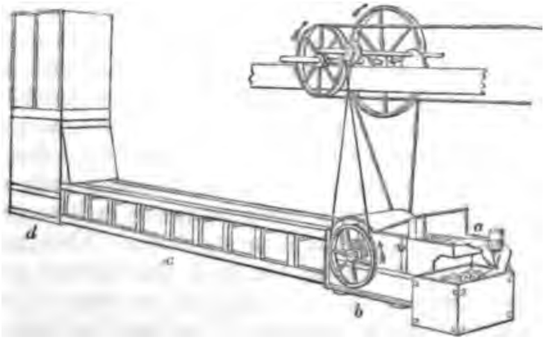
We next trace the progress of the pelt into a room where, to one unused to the din of machinery, everything seems noise and confusion. This is the 'cutting' or 'cropping' room, in which six or eight machines are actively at work, each attended by a female. We Englishmen, happily, know very little of the guillotine, or we should probably find some resemblance between its action and that of the cropping-machine. A long, broad, and sharp blade, having the edge downwards, works very rapidly, with a chopping action; and the pelt being introduced between the blade and a support beneath, the fur is cut from it with a precision that nothing can exceed. The impression on the mind of a visitor is that the pelt must inevitably be chopped to shreds; but, by some admirable adjustment of mechanism, the fur is removed without the skin being cut. The female who attends the machine puts it in or out of work when required, guides the pelt through it, collects the filaments of fur, &c. Such outer fragments or small pieces of the pelt as do not lose their fur by the action of the machine are laid on a table, and women, by the aid of small instruments shaped somewhat like a cheese-cutter, remove the remaining



Cutting Machine.—Fig. 2.

a, the skin, passing between rollers, after the fur has been cut from it; b, the fur deposited in a light layer on an endless cloth.

fur. The denuded skins are useless to the hatter, and are sold at a small price to size-makers in the north of England.



Blowing Engine.—Fig. 3.

a, spot on which the fur is placed; b, box containing the revolving fan; c, hollow trunk through which the fur is blown; d, receptacle where the finer fur is deposited.

We have said that the women in the 'pulling' room cut, tear, or pull out the long coarse hairs from the pelts, and that these hairs are useless to the hatter. But it is impossible completely to separate the coarse from the fine fur by this means; and, therefore, the fur, when cropped from the pelt by the machines, is conveyed to the 'blowing-room,' finally to effect the separation. This room is probably the largest in the factory, and presents a remarkable appearance. It is of small height, but measures, perhaps, fifty feet by forty, having eight hollow boxes or trunks extending nearly the whole length of the room. The action of these hollow machines is exceedingly beautiful, and may, perhaps, be understood without a minute detail of mechanism. A quantity of beaver or other fur is introduced at one end, near a compartment in which a vane or fly is revolving with a velocity of nearly two thousand rotations in a minute. We all know, even from the simple example of a lady's fan, that a body in motion gives rise to a wind or draught; and when the motion is so rapid as is here indicated, the current becomes very powerful. This current of air propels the fur along a hollow trunk to the other end of the machine, and, in so doing, produces an effect which is as remarkable as it is valuable. All the coarse and comparatively valueless fur is deposited on a cloth stretched along the trunk, while the more delicate filaments are blown to a receptacle at the other end. Nothing but a very ingenious arrangement of mechanism could produce a separation so complete as is here effected; but the principle of action is not difficult to understand. If there were no atmosphere, or if an enclosed place were exhausted of air, a guinea and a feather, however unequal in weight, would fall to the ground with equal velocity; but in ordinary circumstances, the guinea would obviously fall more quickly than the feather, because the resistance of the air bears a much larger ratio to the weight of the feather than to that of the guinea. As the resistance of air to a moving body acts more forcibly on a light than on a heavy substance, so likewise does air, when in motion, and acting as a moving force. When particles of sand and gravel are driven by the wind, the lightest particles go to the greatest distance. So it is with the two kinds of fur in the 'blowing machine;' those fibres which are finest and lightest being driven to the remote end of the machine.

We have thus visited those parts of the factory in which the crude materials are prepared for the hatter, and will now, therefore, take our materials to the 'body-makers,' and witness the processes of forming them into a hat.

In one corner of the factory is a dark dingy room, where, around a steaming 'kettle,' we see six or eight men busily employed at some operation, the nature of which can scarcely be divined through the clouds of steam. We pass by them, however, and visit some upper rooms, where the fur and wool are worked up together. The 'body,' or 'foundation,' of a good beaver hat is now generally made of eight parts rabbits' fur, three parts Saxony wool, and one part of lama, vicunia, or 'red' wool. A sufficient quantity of these for one hat (about 2½ ounces) is weighed out and placed in the hands of the 'bower.' On entering the 'bowing-room,' a peculiar twanging noise indicates to the visitor that a stretched cord is in rapid vibration; and the management of this cord by the workman is seen to be one of the many operations in hatting wherein success depends exclusively on skilful manipulation. A bench extends along the front of the room beneath a range of windows, and each 'bower' has a little compartment appropriated to himself. The bow is an ashen staff, from five to seven feet in length, having a strong cord of catgut stretched over bridges at the two ends. The bow is suspended in the middle by a string from the ceiling, whereby it hangs nearly on a level with the workbench, and the workman thus proceeds:—The wool and coarse fur, first separately and afterwards together, are laid on the bench, and the bower, grasping the staff of the bow with his left hand, and plucking the cord with his right by means of a small piece of wood, causes the cord to vibrate rapidly against the wool and fur. By repeating this process for a certain time, all the original clots or assemblages of filaments are perfectly opened and dilated, and the fibres, flying upwards when struck, are by the dexterity of the workman made to fall in nearly equable thickness on the bench, presenting a very light and soft layer of material. Simple as this operation appears to a stranger, years of practice are required for the attainment of proficiency in it.

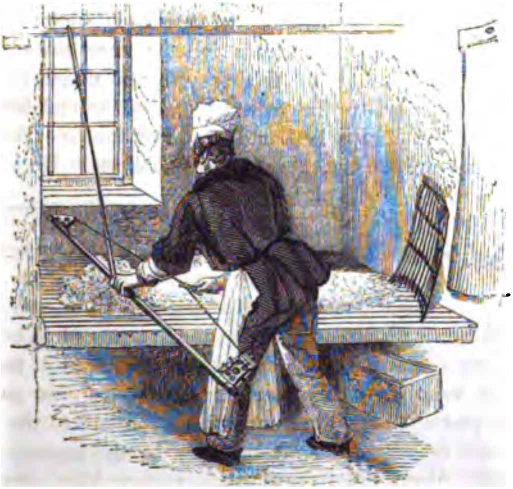
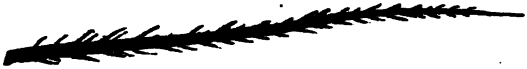


Fig. 4.

The point in the routine of processes at which we have now arrived requires a brief consideration of the operation of felting, on which the whole manufacture of a beaver hat depends. Felting is a process whereby animal fibres are made to cohere and to form a kind of cloth, without the aid of weaving, plaiting, knitting, sewing, or any analogous operation—warmth, moisture, and friction being the means by which it is effected. There is reason to believe that the process of felting was known in early times, and that the tents of the Tartars, as well as some articles of clothing, were produced by these means; but the evidence on this point is rather indistinct. At what time felted wool was first employed for making hats it would be difficult now to say; but there is a legend current among some of the continental hatters which gives the honour to St. Clement, fourth bishop of Rome. Most fraternities love to have a patron saint, when they can find one; and those hatters who regard St. Clement in this light inform us that this holy man, being forced to flee from persecutors, found his feet to be so blistered by long-continued travel, that he was induced to put a little wool between his sandals and the soles of his feet. On continuing his journey, the warmth, moisture, motion, and pressure of the feet worked the wool into a uniformly compact substance. Finally, the wanderer, observing the useful nature of this substance, caused it to be introduced in the manufacture of various articles of apparel.

But leaving St. Clement and his felted 'inner soles,' we may remark that the philosophy of felting was not understood until the microscope was applied to the examination of animal fibres. It was then found that the fibre, whether of wool or fur, is surrounded by a vast number of minute teeth projecting obliquely from the central stem. As these teeth are very sharp and are turned in one direction, they present an obstacle to the motion of the fibre in that direction, but enable it to glide easily in the opposite one; just as an ear of barley, when placed stalk uppermost within the cuff of the coat-sleeve, will soon work its way up to the shoulder by the motion of the arm. In some woolly fibres the irregularities appear like concentric cups, rather than sharp teeth.



Microscopic view of a fibre of beaver fur.—Fig. 5.

When a heap of such fibres is rubbed and pressed, and the fibres made to curl slightly by the action of warmth and moisture, they twist around each other, and the teeth interlace so tightly as not to separate. So complete, indeed, is the entanglement of fibres thus produced, that a coat made from cloth manufactured solely by the felting process has been known to last in wear ten years.

The purpose which the serrated structure of hair or fur is intended to answer is matter for conjecture. With respect to the double fur of such animals as the beaver, the following opinion has been offered:—that, as the beaver passes much of its time in the water, the little projections from the filaments of the inner fur may serve as receptacles whereby the water is prevented from reaching the skin; and that the outer fibres may perhaps act like valves, which, when closed, shield the animal from cold, and when open permit the evaporation of water from the inner fur, and likewise permit respiration to go on from the pores of the skin.

But whatever be the purpose which these arrangements answer in the animal economy, it is evident that the minute serrations on the fibres of fur and wool are the primary source of the felting property. This being understood, we shall be able to comprehend how the fur and wool are worked up into the form of a hat; and we therefore return to the 'bowing' room. The bowed materials for one hat are divided into two portions, each of which is separately pressed with a light wicker frame, and afterwards with a piece of oil-cloth or leather, called a 'hardening-skin,' until, by the pressure of the hands backwards and forwards all over the skin, the fibres are brought closer together, the points of contact multiplied, the serrations made to link together, and a slightly coherent fabric formed. These two halves, or 'batts,' are then formed into a hollow cap by a singular contrivance. One of the 'batts,' nearly triangular in shape, and measuring about half a yard in each direction, being laid flat, a triangular piece of paper, smaller in size than the batt, is laid upon it, and the edges of the batt, being folded over the paper, meet at the upper surface, and thus form a complete envelope to the paper. The two meeting edges are soon made to combine by gentle pressure and friction; and the other batt is laid over the first in a similar way, but having the meeting edges on the opposite side of the paper. The doubled layer, with the enclosed paper, are then folded up in a damp cloth and worked by hand; the workman pressing and bending, rolling and unrolling, until the fibres of the inner layer have incorporated with those of the outer. It is evident that, were there not a piece of paper interposed, the whole of the fibres would be worked together into a mass by the opposite sides felting together; but the paper maintains a vacancy within, and when withdrawn at the edge which is to form the opening of the cap, it leaves the felted material in such a form as to constitute, when stretched open, a hollow cone.

Our visit to this part of the factory has been somewhat lengthy; but the process of transforming the 'bowed' materials into a conical cap is so important, as illustrative of felting, that if this be clearly understood, all that follows will be tolerably plain.

Few 'kettles' are the scene of such busy operations as the hatter's 'kettle,' and few would be so uninviting to a person fastidious as to cleanliness. Imagine a large kettle or boiler open at the top, having a fire beneath it, and eight planks ascending obliquely from the margin, so as to form a sort of octagonal work-bench, five or six feet in diameter, at which eight men may work. The planks are made of lead near the kettle, and of mahogany at the outer part; and at each plank a workman operates on a conical cap, until the process of felting or 'planking' is completed. The 'kettle' contains hot water slightly acidulated with sulphuric acid; and, as far as words can do so, the following may convey an idea of the process:—The cap is dipped into the hot liquor, laid on one of the planks, and subjected to a long felting process: it is rolled and unrolled, twisted, pressed, and rubbed with a piece of leather or wood tied to the palm of the workman's hand, and rolled with a rolling-pin. From time to time the cap is examined, to ascertain whether the thickness of the material is sufficient in every part; and if any defective places appear, they are wetted with a brush dipped in the hot liquor, and a few additional fibres are worked in. Considerable skill is required in order to preserve such an additional thickness of material at one part as shall suffice for the brim of the hat. When this felting process has been continued for about two hours, it is found that the heat, moisture, pressure, and friction have reduced the cap to one half of its former dimensions, the thickness being increased in a proportionate degree.

In many parts of the factory are 'stoving' rooms, in which, by the judicious arrangement of flues, a high temperature is maintained. To such a room the felted or 'planked' cap is taken, and, when dried, it presents the appearance of a fine, stout, and very strong kerseymere, having a drab or greyish colour. There can be little doubt that such a fabric is well calculated to serve the purposes of common broadcloth, provided the means of manufacturing it of large dimensions were ensured.

Is not the reader still puzzled to know how or when the *hat* will make its appearance? We have described numerous materials, and have visited many departments of the factory, but have still produced only a drab-coloured, flexible, conical cap, about fifteen inches wide and fourteen high, as here represented, and without a particle of beaver on its surface. The surface, colour, and form are, however, now about to be changed.

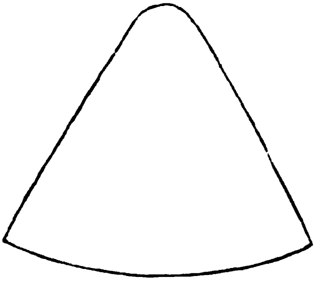


Fig. 6.

In the first place, the cap is taken to the 'water-proofing' room, where the odour of gums, resins, and spirits gives some intimation of the materials employed. Gum-lac, gum-sandrach, gum-mastic, resin, frankincense, copal, caoutchouc, spirits of wine, and spirits of turpentine, are the ingredients (all of a very inflammable nature) of which the water-proofing composition is made. This is laid on the cap by means of a brush, and the workman exercises his skill in regulating the quantity at different parts, since the strength of the future brim and crown depends much on this process.

After another 'stoving,' by which the spirit is evaporated, the exterior of the cap is scoured with a weak alkali, to remove a portion of the gummy coating, and thereby enable the beaver fur afterwards to cling to the woolly fibres of the cap.

Now, for the first time, we have to direct our attention to the fine beaver fur, the purchase and preparation of which are so costly. The washing, plucking, cropping, and blowing departments we have already visited, and have seen the fibres of fur divided into two qualities, of which the finer is that to which the hatter attaches value. This finer quality, which appears to have been formerly known by the name of 'flix,' was, in bygone times, used not only for hats, but also for hosiery purposes—in allusion to which Dyer, in his poem of the 'Fleece,' has these lines:—

> "The beaver's flix
> Gives kindliest warmth to weak, enervate limbs,
> When the pale blood slow rises through the veins."

The fur, being bowed very carefully by a smaller bow than that employed for wool, is spread out into a layer, and by means of the 'hardening-skin' is pressed and worked into a very delicate and light felt, just coherent enough to hold together. This layer, which is called a 'ruffing,' or 'roughing,' is a little larger than the cap body; and, to unite the two, another visit to the 'kettle' is necessary. The cap being softened by submersion in the hot liquor, the 'ruffing' is laid on it, and patted down with a wet brush, a narrow strip of beaver being laid round the inside of the cap, to form the underside of the future brim. The beavered cap is then wrapped in a woollen cloth, submersed frequently in the hot liquor, and rolled on the plank for the space of two hours. The effect of this rubbing and rolling is very curious, and may be illustrated in a simple manner:—If a few fibres of beaver-fur be laid on a piece of broad-cloth, covered with tissue-paper, and rubbed gently with the finger, they will penetrate through the cloth and appear at the opposite side. So, likewise, in the process of 'ruffing,' each fibre of fur is set in motion from root to point, and enters the substance of the felt cap. The hairs proceed in a pretty straight course, and just enter the felt, with the substance of which they form an intimate union. But if the rolling and pressing were continued too long, the hairs would actually pass through the felt, and be seen on the inside instead of the out: the workman, therefore, exer-

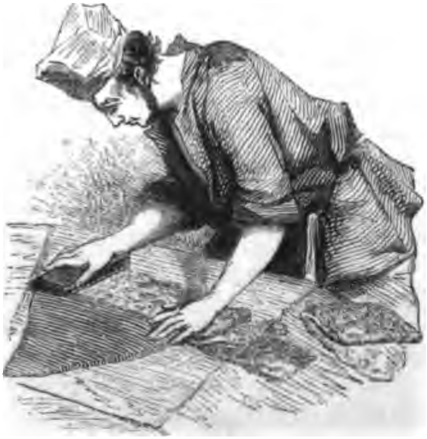


Fig. 7.

cises his judgment in continuing the process only so long as is sufficient to secure the hairs in the felt firm enough to bear the action of the hat-brush in after-days. Eighty or a hundred years ago, when beaver fur was cheap, an "old English gentleman" was wont to have his hat so well beavered, that as much nap felted through it to the inside as remained on the exterior; and when the hat showed symptoms of decay and old age, it was sent to the maker, who turned it inside out, and gave it nearly the pristine freshness of a newly-made hat.

At length the cap is to assume somewhat the shape of a hat, before it finally leaves the 'kettle.' The workman first turns up the edge of the cap to the depth of about an inch and a half; and then draws the peak of the cap back through the centre or axis, so far as not to take out the first fold, but to produce an inner fold of the same depth. The point being turned back again, produces a third fold; and thus the workman proceeds, till the whole has acquired the appearance of a flattish circular piece, consisting of a number of concentric folds or rings, with the peak in the centre. This is laid on the 'plank,' where the workman, keeping the substance hot and wet, pulls, presses, and rubs the centre until he has formed a smooth flat portion equal to the intended crown of the hat. He then takes a cylindrical block, on the flat end of which he applies the flattened central portion of the felt; and by forcing a string down the curved sides of the block, he causes

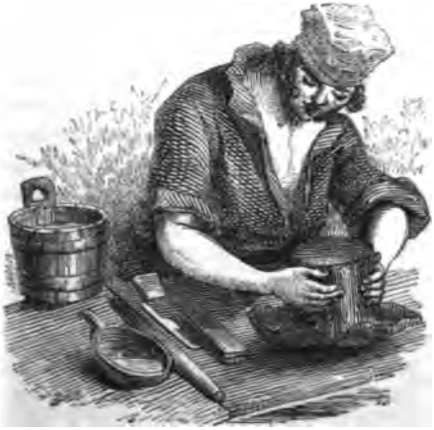


Fig. 8.

the surrounding portion of the felt to assume the figure of the block. The part which is to form the brim now appears as a puckered appendage round the edge of the hat; but this puckered edge is soon brought to a tolerably flat shape by pulling and pressing.

We here terminate our visit to the 'blocking-shop.' The conical cap has been converted into a hat with a flat brim; and we take leave of the 'kettle,' with its hot acid liquor, its wet planks, its clouds of steam, and its ingenious attendants. We will suppose the hat to have been dried in a stoving-room near the great chimney, and will then place it in the hands of the 'shearer.' In an appropriate room, this workman raises and opens the nap of the hats, by means of a peculiar sort of comb; and then shears the hairs to any required length. Connoisseurs in these matters are learned as to the respective merits of 'short naps' and 'long naps;' and by the shearer's dexterity these are regulated. The visitor recognises nothing difficult in this operation; yet years of practice are necessary for the attainment of skill therein; since the workman determines the length of the nap by the peculiar position in which the long light shears are held. A nap or pile as fine as that of velvet can be produced by this operation.

The routine of processes now requires that we should visit the western range of buildings, on the opposite side of Bermondsey Street. At the remote end of the court-yard we see a dark and dismal-looking building, having very little light, and that little received through unglazed windows,—large boiling cauldrons, which it requires some nerve to look into,—a spacious brass cage or frame,—cranes and tackle for raising weights, and a party of workmen whose persons and garments denote the staining effect of the hot dye to which they are exposed. This is the 'dye-house,' where the hats exchange their drab or grey hue for a black one. The dyeing ingredients are logwood and some metallic salts, boiled in certain proportions in soft water. The logwood is imported from Campeachy in logs five or six feet long, and from five to ten inches thick; and a room in this extensive factory is appropriated to the cutting of these logs into fine shreds. For this purpose a powerful revolving wheel, provided with four cutting-blades inserted radially in one of its faces, is employed; the ends of the logs being applied to these blades, the wood is cut into shreds with astonishing force and quickness.

The cauldron with the dyeing ingredients being ready, a number of hats are fixed upon blocks, and the blocks, by means of a hole at one

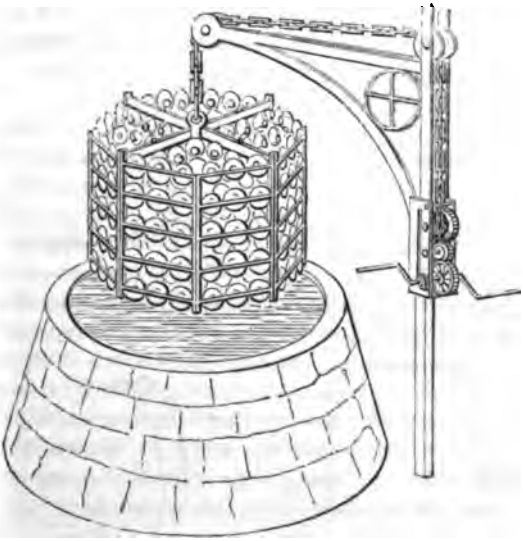


Fig. 9.

end of each, are fixed to brass pegs inserted in a large skeleton frame, so that the hats shall not touch each other. The frame is then lowered into the cauldron, and turned in such a manner as to allow all the hats to be submerged in the dye; after which the frame is hauled up, and the hats allowed to drain for thirty or forty minutes. This alternate submersion and partial drying is repeated twelve or fifteen times, until every fibre of the hat—felt as well as nap—is thoroughly dyed. This is followed by soaking and washing, which frees the surface from impurities; and the hat is then again 'stoved.' A few subsequent processes remove certain irregularities of shape, which the hat has acquired by repeated submersions in the dye-liquor.

We next visit a department of the building where 'finishers' are employed. A boiler is so arranged as to yield a jet of steam, over which the hat is held until thoroughly softened; and having a block shaped in every part nearly as the hat is intended to be, the 'finisher' pulls, rubs, and presses the hat, until it assumes the form of the block; after which the nap is stretched, turned in any required direction, and smoothed, by various sets of brushes, small cushions of velvet, and heated irons. Fig. 10 shows three successive stages in the shaping of the hats, from the first rough 'blocking' to the production of a flat and smooth-edged brim while on the finishing block; likewise a beaver bonnet on the block by which it is shaped.

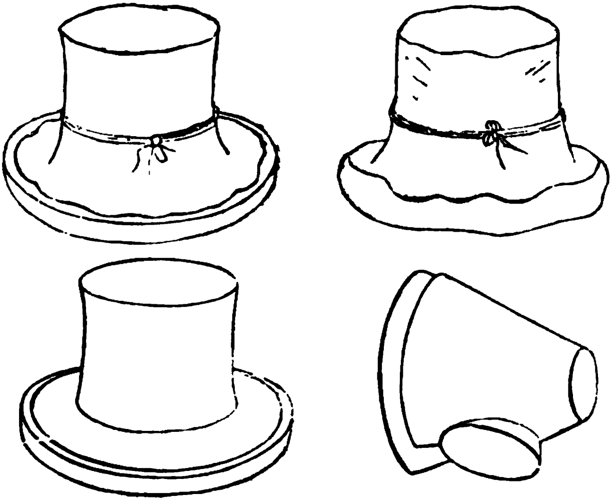


Fig. 10.

Once again we cross to the east range, and visit the first story of a large pile of buildings on the left hand. Here the busy hum of lively voices soon indicates to the visitor the sex of the inmates. We enter a large square room, full of litter and bustle, and find fifty or sixty young females employed in 'trimming' hats, that is, putting on the lining, the leather, the binding, &c. Some are sitting at long tables,—some standing,—others seated round a fire, with their work in their laps; but all plying the industrious needle, and earning an honourable subsistence.

A word or two respecting the employment of females in factories. The texture of English society is such, that the number of reputable employments for females in the middle and humble ranks is very small. Most fathers and brothers are well aware of this; and women themselves, however desirous of contributing to their means of support, are cramped in their efforts by the limited range of avocations left open to them. The effect of this is such as never fails to result when the vineyard is too small for the labourers; the number of employments being few, so many females embark in them that the supply greatly exceeds the demand, and the value of female labour is thereby brought to a very low level. Under such circumstances it is important to inquire how far female labour may be available in factories where the subdivision of employments is carried out on a complete scale; and the factory now under consideration may afford some valuable hints on this point. The number of females employed here is not far short of two hundred, whose earnings vary from eight to fourteen shillings per week. The degree of ingenuity required varies considerably, so as to give scope for different degrees of talent. Among the processes by which a beaver hat is produced, women and girls are employed in the following:—plucking the beaver skins; cropping off the fur; sorting various kinds of wool; plucking and cutting rabbit's wool; shearing the nap of the blocked hat (in some cases); picking out defective fibres of fur; and trimming. Other departments of the factory, unconnected with the manufacture of beaver hats, also give employment to numerous females. Where a uniform system of supervision and of kindness on the part of the proprietors is acted on, no unfavourable effects are to be feared from such an employment of females in a factory. We cannot dwell longer on this matter; but in endeavouring to solve the important problem, "How can all live—and live honestly?" the nature and extent of female employments becomes a prominent subject for thought.

But we have not yet finished our hat. However carefully the process of 'blowing' may be performed, in order to separate the coarse fibres of the fur from the more delicate, there are always a few of the former left mingled with the latter; and these are worked up during the whole of the subsequent processes. Women are employed, therefore, after the hats have left the 'finishers,' in picking out, with small tweezers, such defective fibres as may present themselves at the surface of the hats.

Lastly, the hat is placed in the hands of a workman whose employment requires an accurate eye, and a fertile taste in matters of shape and form: this is the 'shaper.' He has to study the style and fashion of the day, as well as the wishes of individual purchasers, by giving to the brim of the hat such curvatures in various directions as may be needed. Simple as this may appear, the workman who possesses the requisite skill can command a high rate of wages. Fortunate is the 'shaper' who, during a ramble to any place of fashionable resort, can espy a new form of brim,—a curl here, a depression there,—and can imitate it at his work-bench: he will please his employer, and profit himself.

Thus we arrive at the finished state of the beaver hat; and may now leave it to run its career through all weathers,—wet and dry,—cold and heat,—till it is destined to be replaced by a new one. Whether we are contented with the "shocking bad hat" of street phraseology, or have to endure the uneasy pressure of the stiff and glossy new one with fortitude, we must assuredly acknowledge that a beaver hat, considered with reference both to the peculiar processes by which it is produced, and to the number of distinct sets of workpeople (from twenty to twenty-five) through whose hands it passes, occupies an interesting and important place in the manufacturing history of this country.

In tracing the progress of a beaver hat, from the time when the materials are brought into the factory, till the hat is made, trimmed, and shaped, we have carried the reader through the greater part of this large establishment, and have shown the purposes to which the different departments are appropriated. It will, however, be desirable to say a few words respecting the silk-hat department.

As the number of beavers caught annually in America has greatly declined, the price of beaver-fur has of late years increased; and this circumstance has led to the production of a kind of hat which presents some resemblance to beaver, and yet may be produced at a low rate. This is the *silk* hat, the manufacture of which has gone through several stages of improvement, by which even a humble 'gossamer' now presents a neat and glossy exterior.

Silk is wholly incapable of the process of felting, and therefore cannot be employed in the same manner as fur and wool. The body of the silk hat is made either of coarse felted wool, or of some light material, such as willow or stiffened cambric; and on this is placed a covering or hood of silk plush, sewn to the proper size for the hat. The Messrs. Christy weave their own plush at a factory in Lancashire, and send it to London in the form of a soft glossy material, which is cut and sewn by women to the requisite shape of the hats.

The bodies are made in a very rough way, by shaping the willow, cotton, or felted wool round blocks, and using a substance of extra thickness for the brim. A varnish cement is used to join the various parts; and a resinous stiffening composition is laid over the outer surface. Some time before the plush hood is laid on, the body is coated with a peculiar varnish, which, being softened by a heated iron after the hood is laid in its proper position, causes the plush to adhere to the foundation. This process is the most difficult in the silk-hat manufacture; for not only must the plush be made to adhere in every part, but the seam or joining up the side of the hat must be made as little visible as possible. No sewing is here employed; but the two meeting edges are brought precisely together, pressed down with a heated iron, and the silk shag brushed over the joint.

The minuter details of the silk-hat department we must pass over; for, so far as they differ from beaver hatting, they are of much less interest. Beaver hatters look down with some little scorn on the operations of silk hatting; and certainly, so far as regards manipulative skill acquired by long practice, the former branch of handicraft is by far the most remarkable; but still the silk hatter appeals with such moderation to the purse of the purchaser, that we cannot afford to lose sight of him.

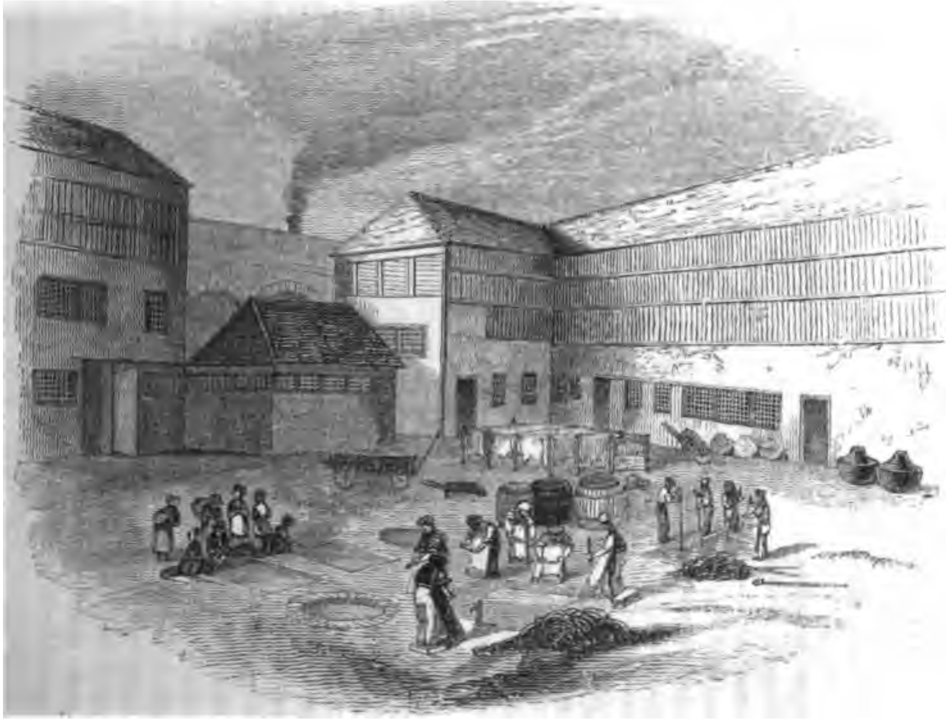
The silk hatters, instead of occupying different parts of the factory, are congregated in one building along the southern side of the avenue leading to the great chimney, the building being divided into numerous small apartments. On the left of the chimney is a range of shops wherein are made common black glazed hats, such as are worn by sailors and persons much exposed to the weather. The bodies of these hats are made of common felted wool, and the outer covering is a thick coating of black varnish or japan, presenting a glossy surface. A high temperature is required for this purpose, and the situation and arrangement of the shops are such as to insure this temperature.

There is a distinct range of apartments in which seal-skin and other skin or fur caps are made. In these, unlike beaver hats, the fur is not cut from the pelt and then felted; but the pelt, with the fur remaining on it, is dressed into leather, and is cut up into such pieces as may, by subsequent processes, be formed into caps of various shapes.

Another department entirely distinct from the rest, is that in which cloth caps of various kinds are made. This, generally speaking, is effected by needlework, and wholly differs from the processes of hatmaking.

Here we terminate our visit to an establishment which presents so considerable a number of interesting processes. We have selected that of Messrs. Christy, because, from the completeness and systematic arrangement of the details, it well illustrates the economy of a large factory,—the concentration of many departments within the walls of one establishment, the division of labour, the exercise of delegated authority by foremen to each department, and a general supervision of the whole by the proprietors. It is difficult to estimate the area of ground covered by all the workshops; but the reader may, from the foregoing details, form some idea of the numerous piles of building constituting the factory. There are many establishments in and near London, such as water-works, gas-works, ship-yards, tan-yards, brewhouses, distilleries, glass-works, &c., the extent of which would excite no little surprise in those who for the first time visited them. Indeed the densely packed masses of building forming the eastern districts of the metropolis, on both sides of the river, include individual establishments which, although they would appear like little towns if isolated, scarcely meet the eye of a passenger through the crowded streets.

We may here remark, as a completion of this notice of the hat manufacture generally, that the making of straw hats, so much worn in country places, is in the hands of a class of persons altogether different from those engaged in the other branches of hatting. The finer qualities of straw, as well as white whalebone and white chip, are used for bonnets rather than for hats; but the mode of manufacture is nearly the same in all. There are delicate planing-machines in use, by which any soft kind of wood can be cut into thin shavings, and the shavings, at the same time, cut into very narrow strips with great precision. Such is the case with willow, and also with whalebone. The willow of which the foundations of silk hats are frequently made is prepared in some such way as this; the narrow strips of willow being plaited, or perhaps we might say woven, into a square sheet sufficiently large for three hats. A slight glance at the willow foundation of a silk hat will show the nature of the material, and will also show that the mode in which the narrow strips are linked together resembles weaving rather than plaiting. It is not difficult to imagine, from these few details, that a hat or bonnet may be made from any such materials as whalebone, wood, straw, cane, rush, or others wherein a longitudinal fibrous structure is found; and the reader will readily call to mind numerous examples of such an application of fibrous materials.



VIII.—Neckinger Mills Leather-Manufactory, Bermondsey.—Face p 161.

VIII.—A DAY AT A LEATHER-FACTORY.

The subject of the present article, as of the last, takes us to a part of the metropolis remarkably distinguished for its manufacturing features. Bermondsey has been for many years the principal seat of the leather-manufacture in England, and derives from this circumstance a character and appearance different from those presented by any other district in London. The cause to which this localization seems to be most correctly assigned, is the existence in Bermondsey of a series of tide-streams, which, twice in every twenty-four hours, supply a large quantity of water from the Thames for the use of the tanners and leather-dressers. The construction of Artesian wells has now in some measure diminished the employment of the water from these streams; but the streams still remain, and are still employed by many of the manufacturers.

The processes involved in the fabrication of leather, although in many respects remarkable and interesting, are very little understood beyond the circle of manufacturers and dealers. It is generally known that the avocations of the tanner, the currier, the fellmonger, the tawer, the leather-dresser, all relate in some way or other to the preparation of leather; but the relation which these employments bear one to another is not so well understood. The establishment to which our visit has been made for the purpose of this article, is connected with the production of some only of the various kinds of leather; but we hope to be able to give a general outline of the manufacture as a whole.

Leather has been designated by Dr. Ure as "the skin of animals, so modified by chemical means as to have become unalterable by the external agents which tend to decompose it in its natural state." The gelatinous portion of the skin is made to combine with chemical substances artificially applied, and by this combination the new substance, leather, is produced. The ingredients employed for the conversion of skin into leather are different in different cases, and give rise to various subdivisions of employment in the leather-manufacture. The classification of the different kinds of leather might be made according to the animals whence the skins were obtained, or according to the thickness and quality of the skins, or according to the purposes to which the prepared leather is to be applied: but we think that the purpose of the present article will be better answered by making a classification according to the mode of manufacture; and we shall therefore speak of leather as prepared —1st, by *oak-bark;* 2nd, by *sumach;* 3rd, by *alum;* and 4th, by *oil:* these four varieties being remarkably distinguished one from another.

The leather prepared by *tanning with oak-bark* is the hide of the ox, the calf, and the horse, all of which possess sufficient firmness to be applied to the manufacture of shoes, harness, and other articles requiring great strength and durability. The skins prepared by a substance called *sumach* are principally those of the goat and the sheep; and the leather resulting from the process is *morocco leather*, for coach-linings, chair-covers, book-binding, ladies' shoes, &c.; *roan* for shoes, slippers, and common book-binding; and *skiver*, an inferior leather, for hat-linings, pocket-books, work-boxes, toys, and other cheap purposes. The skins dressed in *alum* are principally those of the kid, the sheep, the lamb, and in some instances the calf; and the leather produced is principally employed for gloves and ladies' shoes. Lastly, the skins dressed in *oil* are those of the sheep, the buck, and the doe; and the resulting leather is that of which riding-gloves and similar articles are made, as well as the soft wash-leather, or shamoy leather, familiar to every one.

Although the processes whereby these varieties of leather are produced differ very distinctly one from another, yet the establishments wherein they are conducted present a generally similar appearance. The tan-yards and leather-manufactories of Bermondsey each present to the view of a stranger an open court or yard surrounded or partially surrounded by buildings, some of which are so constructed as to admit the access of air to every part of the interior. The surface of the court or yard is in most cases intersected by pits, or square cisterns, in which the skins are steeped during some part of the manufacturing process. All bear a general resemblance, too, in two circumstances not altogether attractive to visitors, viz., the presence of unpleasant odours, and the absence of cleanliness.

1. *Leather prepared by Tanning.*—When an ox has been slaughtered, the hide removed, and the flesh transferred to the butcher, the hide is sold to the tanner, by him to be converted into the thicker kinds of

leather. The hide passes into his hands with the horns attached; and he separates these from the hide, and sells them to the comb-makers and other manufacturers of horn. The hair is also attached to the hide, but the removal of this is a more difficult operation.

When the hide is purchased by the tanner, there are little bits of flesh, &c. adhering to the inner surface; and these are removed by a process called 'fleshing.' The hide is spread out over a convex wooden bench called a 'beam,' and is then scraped with knives of a peculiar shape, by which all extraneous matters are removed, and the hide is pared down to the cutis. After this process the hair is to be removed, and this is effected in one of two ways, according to the nature of the skin. One method consists in mixing together quick-lime and water, and immersing the hide in the solution: after remaining there several days, and having the lime-water renewed occasionally, the bulbous roots of the hair have become so far loosened by the action of the lime as to be easily pulled out. The hide is then spread out on the beam, and 'unhaired,' that is, scraped with a knife till the hair is removed. In the other method, adopted in some kinds of skins which would be injured by the action of lime, several skins or hides are placed in a close chamber, where they undergo a kind of natural fermentation, sufficient to loosen the hair from the skin.

When by either of these methods the hair has been removed, the hide is 'grained,' or scraped, and then subjected to a process whereby the pores are opened, and prepared for the reception of the *tan* afterwards to be applied. In some cases this consists in steeping the hide for some days in a sour solution of rye or barley flour; in others the bath is a very weak solution of sulphuric acid in water. The hide becomes swollen, softened, and the pores ready prepared for the reception of the tan.

The bark, the roots, and occasionally the leaves of a considerable number of plants yield, by soaking in water, an astringent solution, usually of a yellowish brown colour. This solution has a peculiar action on the living skin, corrugating and constringing it; and when applied to dead skin, has the property of converting it into leather. These vegetable substances contain a principle called *tannin*, which is the agent concerned in converting skin into leather. Provided the tannin is obtained, it matters not much to the success of the process what substance yields it; and the tanner, therefore, employs that which is, on the whole, the most effective and the most economical.

To detail the various systems adopted by different tanners would be wholly foreign to our purpose. The process is so slow a one, and the desirability of increased speed so great, that patent after patent is taken out on the subject; and almost every tanner has some process peculiar to his own establishment. We must, therefore, be as general as possible in our few details. When the hide is properly cleaned and brought to the state called 'pelt,' it is ready to be placed in one of the tan-pits. These pits are generally rectangular cisterns, whose upper edge is level with the ground, and whose interior is lined with wood. The tanning ingredient, generally oak-bark, is steeped in the cistern of water, and the solution is then technically termed 'ooze.' The hide is in the first instance put into a pit containing nearly-spent ooze, in which hides have already been steeped, and which has consequently lost more or less of its tanning principle. In this pit the hide is frequently stirred and turned to insure the equable action of the tan on every part. The hide is then transferred to a pit containing stronger ooze, or else is stratified with crushed bark; several hides being laid one on another, and steeped in water. Whether the hides be placed at once in prepared solution of bark, or be stratified with bark in a pit containing water, depends upon the system of tanning pursued by the manufacturer, and upon the quality of the hide; but in either case the hides are exposed to renewed portions of the tannin ingredient from time to time, until the tannin has combined intimately with the animal substance. In most tanneries several months are consumed in this process of steeping in the tan-pits; and although numerous patents have been granted for improved and more expeditious processes, the limited extent to which these are adopted seems to show that there is some advantage afforded by lengthened time, not altogether attained by the speedier processes. Without enlarging on this point, it will suffice to say that the object of tanning, whether by a slow or a speedy process, is to cause the tanning principle to penetrate into all the pores of the hide from surface to surface: when this is effected, the hide has become transformed into leather. When the hide is tanned, it is hung up in an airy loft, or drying-room; and during the process of drying is compressed by beating, by pressure with a steel instrument, or by being passed between rollers, which gives it a smooth and dense texture.

The stoutest hides, from bulls, buffaloes, oxen, and cows, are tanned in a way more or less resembling that above detailed, and are then used principally for the soles of boots and shoes. The time employed in tanning a hide for the soles of men's boots in general is from six to twelve months; while a still thicker quality, known as 'butts' or 'backs,' frequently consumes fifteen or eighteen months in the process. The skins of calves, seals, and the lighter kinds of horse and cow skins, are tanned to form the 'upper leathers' of boots and shoes, and are prepared in a somewhat similar but more expeditious manner. After having been 'unhaired,' they are steeped for eight or ten days in an alkaline liquor, being at intervals taken out and scraped on both surfaces, by which the lime, oil, and gelatinous matter are forced out from between the pores, and the skin rendered soft, pliant, and fit to receive the tanning ingredient. They are then exposed to the action of tan in the tan-pits until converted into leather.

Leather intended for the upper parts of boots and shoes, for saddlers, and for coach-makers, passes into the hands of the currier after tanning, for the purpose of being softened, equalized in thickness, smoothed, blacked, &c. The currier dips the tanned skin in water to moisten it, and then softens the texture by beating it with a 'mace;' an instrument consisting of a wooden handle two or three feet long, with a cubical head at one end. He then places the skin on an inclined plane called a 'horse,' and equalizes the thickness by the aid of a broad, straight, two-handled knife, called a 'cleaner,' which is worked in such a manner as to shave off the superfluous thickness of the skin. After this the leather is thrown again into water, and rubbed on the grain or outer side with pumice or grit-stone; whereby the 'bloom,' a whitish matter derived from the action of the bark, is removed. The leather is then rendered flexible by being rubbed, first on one side, and then on the other, with an instrument called a 'pommel,' consisting of a piece of wood fastened to the hand by a strap on one side, and having on the under surface a number of parallel grooves, which have the effect of bringing the leather to a high state of flexibility. The leather is again scraped with a broad knife to equalize its thickness and texture. Then, according to the quality of the leather, and the purposes to which it is to be applied, it is dressed with oil, with oil and lampblack, with tallow, &c.; and is polished with rubbers of hard wood.

2. *Leather prepared with Sumach.*—We now come to those varieties of leather which will enable us to refer more particularly to the establishment selected for our visit on this occasion; viz., the manufactory known as the Neckinger Mills in Bermondsey, owned by the

Messrs. Bevington, and in which nearly all the kinds of leather prepared with sumach, alum, or oil are manufactured.

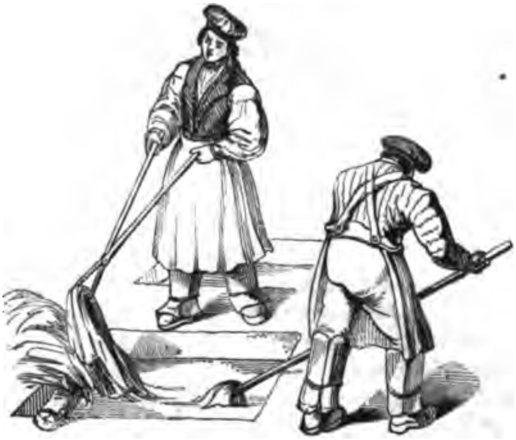
In proceeding from Bermondsey Old Church towards the Greenwich Railway, along the Neckinger Road, we arrive at the Neckinger Mills, at a short distance westward of the railway; indeed, the latter passes through part of the ground formerly belonging to the manufactory. The term 'mills' is applied because the premises were once occupied by a company formed for the manufacture of paper from straw, and were then known as paper-mills; the water for the manufacture being supplied by the Neckinger tide-stream, which flows past the building twice a-day from the Thames. About forty years ago the spot became a leather manufactory, but the term Neckinger Mills continues to be applied to it.

On entering the gates which form the communication from the high road to the factory, we find ourselves in the open yard represented in the frontispiece. In various parts of this yard are pits, some rectangular and some circular, used not as tan-pits, for tanning skins, but as lime-pits for loosening the hair and wool. Here and there are men employed in 'drawing,' or lifting out the partially limed skins, and in transferring them from place to place. Southward of this yard is another, occupied principally by lime-pits similar to the others, and by lines whereon wetted skins are hanging to dry. Around the large or principal yard are ranges of buildings employed for various purposes. In one range are extensive ware-rooms for finished leather of the morocco kind; in another the white leather is contained; over these are drying-lofts, in which the skins are hung at a certain stage in their manufacture. In another part of the premises are the vessels for tanning skins with sumach; in a third the dye-house, where the morocco leathers are dyed; in others are three or four leather-splitting machines, fulling-stocks for shamoy leather, a rotating vessel for alumed leather, and various other arrangements, of which we shall speak presently. The large quantity of water employed in the several branches of the manufacture, and the necessarily dirty processes involved, keep the greater part of the buildings in a wet and sloppy state; and the existence of several dozens of cisterns or pits in the open yards render necessary some little circumspection in the steps of a visitor: indeed this circumspection is desirable on more accounts than one, for there is a sort of 'standing-order' among the workmen, that although an immersion in one of the pits is open to any one, the extrication from it is valued at half-a-crown.

The most important leather prepared by tanning with sumach is the morocco-leather made from goat-skins. The term 'Morocco' is probably derived from the country of that name, but we are not aware whether this species of leather was originally manufactured there. Be this as it may, the finer kinds of morocco leather, employed for coach-linings, chair-covers, &c., are prepared from goat-skins; while the inferior or 'imitation' morocco, applied to purposes wherein cheapness is desired, is made from sheep-skin. Morocco is familiarly known to most persons as a glossy-coloured leather, whose surface presents a wrinkled and fibrous appearance; and we perhaps cannot better illustrate the process of preparing leather by sumach than by tracing the manufacture of this variety.

The goat-skins employed for this purpose are imported from various parts of the world—Switzerland, Germany, Memel, Mogadore in Northern Africa, the East Indies, the Cape of Good Hope, Asia Minor, and other places. The skins from some places are preferred on account of their thickness or good quality; from others on account of their size; while others are purchased according to the supply which may happen to be in the market. The skins are imported with the hair on, and to remove this is one of the first processes of the manufacture. The goat-skins are first soaked in water for several days to soften them, and then undergo the process of 'breaking,' that is, scraping them on the flesh side to remove the adherent substances which would interfere with the process of tanning. The 'fleshings' and other scraps obtained in processes similar to this are placed on open racks or stages exposed to the air, and when dry are sold to the manufacturers of glue and size; as are likewise the fleshings and other scraps from the thicker hides and skins prepared by the tanner. In large establishments this apparently useless offal is worth many hundred pounds per annum to the proprietors.

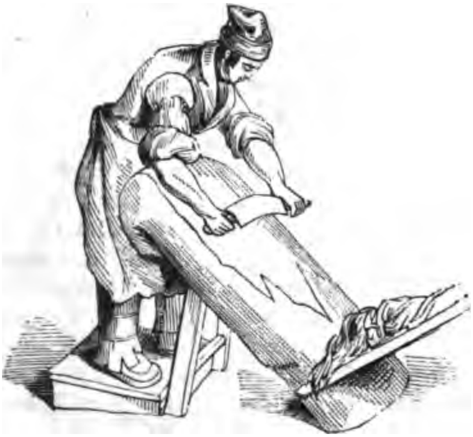
Into the lime-pits before noticed a solution of lime in water is conveyed, and the goat-skins, after being fleshed, are allowed to soak therein for four or five weeks. During this time they are frequently 'drawn,' a process represented in Fig. 2, and consisting in taking the skins out of the pit, laying them in a heap on the side, allowing them to lie thus for a certain time, and immersing them again: all this has the effect of causing the lime to act equally on



Drawing Goat-skins.—Fig. 2.

every part of the hairy covering; and the lime-water is renewed once or twice, to aid in producing the desired effect.

When the liming has been carried to such an extent that the hair can be easily pulled out with the finger, the goat-skins are drawn from the pits, and conveyed in wheelbarrows to the 'fleshing-shop,' one of the buildings in the western part of the premises. In this shop are a number of 'beams,' consisting of convex work-benches or stools sloping downwards from one end to the other, and supported on a frame or stand. Each goat-skin is laid smoothly on a 'beam,' with the hairy side uppermost; and the workman, standing at the upper end of the beam, scrapes off all the hair by means of a double-handled knife. The convex form of the surface on which the skin is laid, and the peculiar form given to the knife, enable the workman to take off all the hair very completely. The operations of 'fleshing,' of 'unhairing,' and of 'graining,' are so nearly alike in their general appearance, that Fig. 3 will sufficiently show the character of the whole, the principal difference being in the edge of the knife employed by the workman. The hair which is thus removed from the goat-skins is, after being cleansed, sold to the carpet-manufacturers and to plasterers.—A glance at the wooden shoes and the 'overalls'



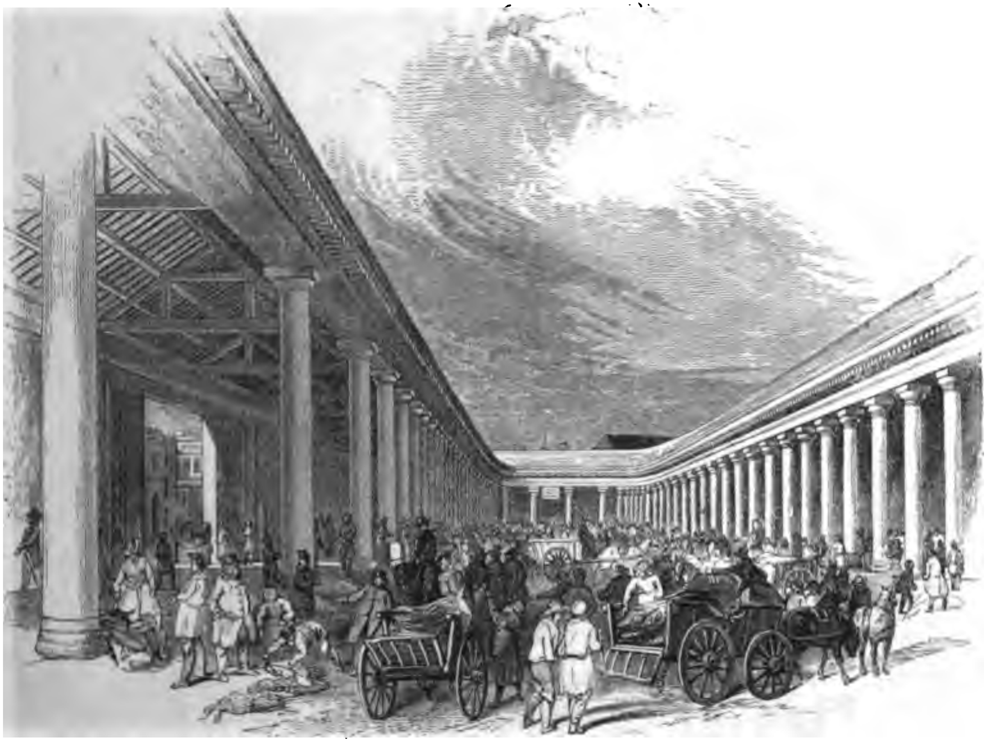
Unhairing a Goat-skin.—Fig. 3.

worn by the workmen in this and similar parts of the leather manufacture will satisfy a visitor, even if his own clothes escape mischief, that the occupation is not one of the most cleanly.

After the process of 'unhairing,' the goat-skins are again soaked in lime-water for two or three days, and are then again 'fleshed,' or scraped on the inner surface, by which the cutis is brought to a tolerably clean state. But the long steeping which the skin has undergone has had the effect of driving the lime into the pores, insomuch that the tanning principle contained in the sumach, afterwards to be applied, cannot reach the heart of the skin. The tanning, therefore, cannot be commenced until the lime is removed, and the pores opened. The means adopted for effecting this are by far the most disagreeable in the whole range of the manufacture. A solution called the 'pure' or the 'pewer', (having never seen the word written or printed, we must spell it as pronounced) is prepared in a large vessel, and into this the skins are immersed: there is an alkaline quality in the solution employed, which has the effect of removing the lime from the pores, and the manufacturers seem to have failed hitherto in finding more than one, substance which yields this quality effectually. Whether chemistry may hereafter afford them a more extensive range it is not for us to say, but such would seem to be at least probable. After being 'pured' for some time, the skins are taken out and scraped well on both sides, for the sake of removing as much of the lime and the albumen as may be removable by these means; and after this they are steeped again.

By these operations the pores of the goat-skin are so far opened and cleared as to prepare them for the reception of the tanning principle. The substance employed in tanning stout hides is, as we before explained, oak-bark; but for goat-skins the tanning ingredient is a vegetable substance called *sumach*. This is the powder of the leaves, peduncles, and young branches of a plant called the *Rhus coriaria*, growing in Sicily, Italy, and Hungary. It is one of the substances experimented on by Sir H. Davy in his inquiry into the tanning properties of various bodies; and he found it to contain a large proportion of tannin. It contains also a light colouring-matter, which seems to render it useful for the tanning of light-coloured leathers. It is employed extensively in dyeing, as well as in leather-dressing. In the sumach tan-houses at Messrs. Bevington's we saw a pile of this substance, just as imported from Sicily, in cloth bags containing about one cwt. each: when the bags are opened, the sumach appears as a fine yellow powder.

The manner in which this tanning ingredient is forced into the pores of the goat-skin is exceedingly curious. The sumach is mixed with water; but if the skins were immersed indiscriminately in the solution, or even laid smoothly one on another, the sumach would not act equally on the whole surface. To produce the desired equality of action, the following singular plan is adopted:—The wet goat-skins are taken from the 'pure,' or alkaline solution, and sewn up by women into bags, each skin forming a bag with the grain side outwards, and having no opening except a small one at that part which had formed the hind shank of the animal. These bags, as soon as made, are thrown into a vessel of water, and examined, to see that they are well sewn up, and free from holes. They are then taken to the sumach-tub, where the process represented in Fig. 4 is carried on. A large shallow circular tub, twelve or fifteen feet in diameter, is filled with hot water containing a little sumach, and near it is a smaller vessel containing a strong solution of sumach in water. Two men and a boy, standing on one side of the tub, then begin to fill the bags with the sumach-solution. The boy takes a bag, and inserts into its mouth the stem of a funnel, the mouth of which is uppermost. One of the men then nearly fills the bag, through the



Skin Depository of the New Leather and Skin Market, Bermondsey, 1842.—Face p. 175.

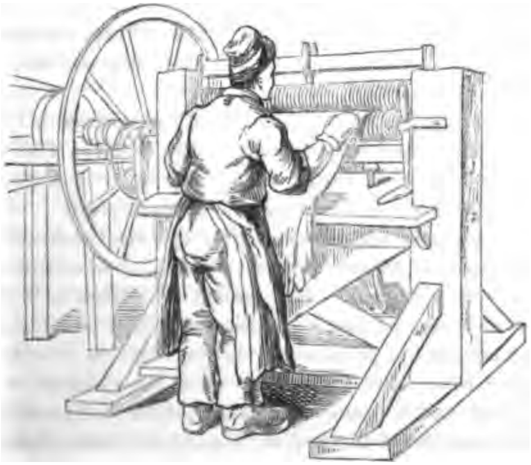
goat-skin thus:—The workman lays the skin on a sloping bench, with the dyed surface uppermost, and rubs it forcibly with a ball made of some hard wood, such as box. The ball is about the size of a small lemon, and has on its surface a number of fine parallel grooves. As the ball is worked over the leather in the direction of these grooves, it leaves permanent marks thereon, and thus gives rise to the appearance which distinguishes morocco from all other kinds of leather. Nothing can exceed the beauty and flexibility of the morocco leather made from the finest goat-skins: the finishing by means of the grooved ball makes the leather very pliable, while the nature of the skin itself gives it great durability and toughness. In the morocco ware-room at the Neckinger Mills the vivid colours displayed show also that this kind of leather is susceptible of receiving a beautiful dye.

We have before stated that there is an inferior kind of morocco leather, made of sheep-skin. This, under the name of 'imitation' morocco, is largely used for inferior or economical purposes; and though it is inferior to the other kind in suppleness and durability, its superficial appearance is very nearly equal: indeed it is to this latter fact, combined with greater cheapness, that we may attribute its extensive manufacture. In the manufacture of morocco leather from sheep-skins there are not many points of difference from the analogous manufacture from goat-skins; but it will be necessary to speak briefly of the different states in which the skins come into the hands of the leather-dresser.

There are in Bermondsey about twenty or thirty manufacturers called *fellmongers*, whose business it is to bring sheep-skins into a certain state of preparation before the leather-dresser commences his operations thereon. The skins from nearly all the sheep slaughtered in London are conveyed to a Skin-Market in the western part of Bermondsey, and there sold by factors or salesmen, who act for the butchers, to the fellmongers. The skins are bought and sold with the wool on, and the labours of the fellmonger relate to the separation of the one from the other, and the disposal of the wool to the woolstaplers, most of whom live also in Bermondsey, and the 'pelts' or stripped skins to the leather-dressers and the parchment-makers. The trade of a fellmonger is more dirty and disagreeable than even that of a leather-dresser, on account of the methods necessary to be adopted for the separation of the wool from the pelt. These remarks, so far as the leather-dresser is concerned, apply only to sheep-skins; for the skins of the goat, the kid, the buck, the doe, and one or two other kinds of animals which have a hairy rather than a woolly covering, come into his hands before the hair has been removed; and the process of 'unhairing' is then effected.

In the manufacture of sheep-skins into 'imitation' morocco, and into roan leather, a routine of operations occurs not very different from that sketched above. Both kinds are prepared by sumach-tanning; and the preparatory and subsequent processes are for the most part similar to those necessary for goat-skin morocco. There are, however, one or two points of difference which must be noticed. The skin of the sheep, from the organization which promotes the rapid growth of wool, contains a much larger amount of grease, or oleaginous matter, than the skin of the goat; and it is essential that this be removed before the tanning principle is brought to act upon the skin. To effect this, the skins, shortly before being placed in the sumach-tan, are subjected to the action of a hydrostatic press, which by a pressure of many tons forces out the extraneous matters from the pores of the skin. The kind of leather called 'roan' does not present the wrinkled or grained appearance of morocco leather—a difference which results from the different mode of finishing after the dyeing; the grooved balls not being used for the roan leathers.

The kind of sheep-skin leather called 'skiver,' used for common bookbinding, hat-linings, pocket-books, work-box covers, and other cheap purposes, deserves notice for a process the most remarkable in a mechanical point of view which the Neckinger establishment presents; we mean the 'splitting' of a skin into two thinner skins. Thin as a sheep-skin is, and supple when wetted, it might be thought that the operation of splitting or slicing it into halves, without cutting holes in either, would be an impossible task; yet this is effected with the utmost accuracy. We have seen, at a large tannery in Bermondsey, a machine for splitting hides; but the small thickness of a sheep-skin requires peculiar arrangements for effecting a similar bisection. The object aimed at in this operation is twofold, viz., to obtain a thin kind of leather for some purposes for which a sheep-skin in the natural state would be too thick, and to obtain a quality of leather which would be sold at a lower price than that made from whole skin. The principle of the machine is this:—Two rollers, ranged horizontally in a frame, are made to rotate in opposite directions, the vacancy between them being only just sufficient to admit a soft wetted sheep-skin or pelt. The rotation of the rollers causes the skins to be drawn slowly between them; but it cannot do so without encountering the blade of a very sharp knife, which has a reciprocating horizontal motion, in such a position as to cut the skin into two thicknesses as it passes the knife, one-half passing over, and the other under the blade. A most ingenious contrivance is adopted for yielding to any inequalities which may occur in the skin. One of the rollers is made in several pieces, so adjusted that in passing over any thickened portions of the skin the common aperture between the rollers is widened at that part. It is one of the consequences of the construction of the machine, that one of the semi-thicknesses or sections of the skin must be equable and level in every part, while any inequalities which might have existed in the original skin will be thrown into the other section. Either section, the 'grain' side or the 'flesh' side, may have this equable thickness given to it, according to the mode in which the skin is adjusted on the rollers; and the two portions may have various ratios given to their thicknesses, according to the position of the vibrating knife opposite the opening between the rollers. These machines, of which there are three or four in the Neckinger factory, were patented by the proprietors several years ago, and exhibit very beautiful mechanical arrangements. A sheep-skin of the usual size occupies about two minutes in splitting, during which time the knife makes from two to three thousand



Skin-splitting Machine.—Fig. 6.

vibratory motions to and fro, cutting a minute portion of the skin at each movement. Fig. 6 represents a sheep-skin undergoing the process of splitting in one of these machines.

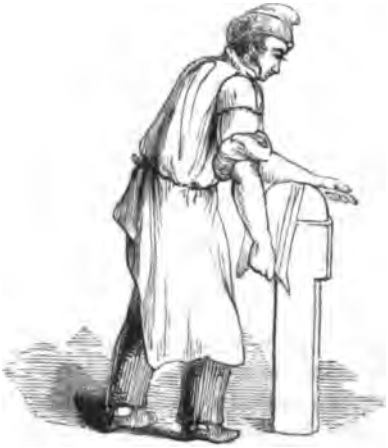
As the thin 'skivers' are more readily acted on by the sumach-tan than the thicker goat-skins, they are not sewn up into bags like the latter, but are immersed in the sumach-tub in an open state, and are tanned in a very short space of time. The subsequent operations require less delicacy than in the preparation of morocco leather, and do not call for much remark.

Among the varieties of leather tanned with sumach is the 'enamelled leather,' now occasionally employed for ladies' shoes. This is made of seal-skin or thin calf-skin, coated, after tanning, with a peculiar kind of varnish or japan capable of yielding a brilliant gloss.

3. *Leather prepared with Alum.*—The technical name of 'tawing' is frequently applied to the general routine of operations whereby alumed leather is produced. This variety of leather is in many cases left white or undyed, and has a peculiar softness when finished. The skins which undergo the process of 'tawing' are those of the kid, the sheep, and the lamb; the first-named of which yield the well-known 'kid leather' of which gloves and ladies' shoes are made; while the white leather made from sheep-skin is used for lining shoes and other inferior purposes. The cheap kid gloves which are displayed in the shop-window of the hosier are generally made from lamb-skin, and may be considered as an 'imitation' kid.

The kid-skins which form the staple of this branch of the manufacture are brought from Italy: they are very small in size, and have the hair on. The first operation to which they are subjected is steeping for the space of three days, by which they become soaked and softened: they are then 'broken' on the flesh side, a process resembling that to which goat-skins are subjected: the skin is laid on a beam or convex bench, with the flesh side uppermost, and is then scraped: this seems to facilitate the action of the lime in the next process. After the 'breaking,' the kid-skin is immersed in lime-water in a pit for about fourteen or sixteen days, by which the hair becomes in some measure loosened from the pelt; and at the end of this period the operation of 'unhairing' is effected in the same manner as for goat-skins. In a few days after this process the skin is 'fleshed,' to procure a clean surface on the inner side, and after this the pores are opened and the lime 'killed' (to use a technical term). This opening of the pores is effected not by the alkaline solution called the 'pure,' as in goat-skin dressing, but by steeping the skin in a solution or 'drench' of bran and water. When this is effected, the skin is laid down on the 'beam' with the grain-side uppermost, and 'struck,' or forcibly worked with a knife, whereby the impurities are worked out from within the pores. After a further steeping for a day or two in bran and water, the skin is in a state to undergo that process which constitutes the principal difference between sumached leather and alumed leather. Instead of being sewn up into bags filled with sumach liquor, and immersed in a tub of hot water, the skins are put into a kind of barrel called a 'roundabout:' this barrel has a door or opening in one part of its curved surface, through which the skins are placed; and when the water and ingredients are added, the door is closed, and the barrel made to rotate rapidly. The effect of the rotation is to cause the impregnated liquor to act intimately on every part of the skin. The substances placed in the barrel to act on this skin are, for the commoner kinds of leather, alum and salt; and for the better kinds, alum, salt, flour, and yolk of eggs: these latter ingredients are for the most part absorbed into the substance of the finer kid leathers, and seem to have the effect of imparting that beautiful softness and plumpness which such leather presents. About twelve pounds of alum and a little more of common salt are sufficient for about two hundred skins. Sometimes the skins are not put into the 'roundabout,' but are merely steeped in the solution in an open tub: whether the one or the other plan be adopted, however, a period of five minutes is sufficient to produce the effect. In that part of the 'tawing' process wherein eggs are employed, the eggs are broken, in the proportion of one to each skin, and the yolks only are mixed with water and a little meal in a tub: the skins are then introduced, and are trampled by the naked feet of a man until the egg has been thoroughly imbibed. The eggs employed for this process are imported from France: sixty or seventy thousand are purchased for the Neckinger factory every spring, and are preserved in lime-water till wanted, a mode by which they may be kept perfectly sweet for two years.

The tawed skins, after being hung up in a loft to dry, are stretched out, smoothed, and softened, by the process of 'staking,' represented in Fig. 7. In one of the upper rooms of the establishment are a number of wooden blocks, having at the upper end a steel instrument, shaped somewhat like a cheese-cutter, but not having a very sharp edge. Over the semicircular edge of this instrument each skin is drawn very forcibly, the workman holding it in both hands, and



Staking tawed leather.—Fig. 7.

scraping the surface in various directions on the steel edge. This has the effect of stretching out the skin to its full extent, and of removing all the rigidity and stiffness which it had acquired in the previous processes. This is, indeed, one of the many processes of violent rubbing, scraping, or friction to which every kind of leather is more or less subject in the progress of manufacture; but in this instance the rubbing is effected when the leather is nearly in a dry state.

For the production of 'imitation' kid leathers the skin of lambs is employed; and for this purpose lamb-skins are imported from the shores of the Mediterranean. They are imported with the wool yet on them, and as this wool is valuable, the leather-manufacturer carefully removes this before the operations on the pelt commence. The wool is of a quality which would be greatly injured by the contact of lime; and therefore a kind of natural fermentation is brought about as a means of loosening the wool from the pelt. At the Neckinger establishment, one of the buildings presents, on the ground-floor, a flight of stone steps leading down to a range of subterranean vaults, or close-rooms, into which the lamb-skins are introduced, in a wet state, after having been steeped in water, 'broken' on the flesh side, and drained. The temperature of these rooms is nearly the same all the year round—a result obtained by having them excluded as much as possible from the variations of external temperature; and the result is that the skins undergo a kind of putrefactive or fermenting process, by which the wool becomes loosened from the pelt. During this chemical change, ammonia is evolved in great abundance: the odour is strong and disagreeable: a lighted candle, if introduced, would be instantly extinguished; and injurious effects would be experienced by a person remaining long in one of the rooms. Each room is about ten feet square, and is provided with rails and bars whereon to hang the lamb-skins. The doors from all the rooms open into one common passage or vault, and are kept close except when the skins are inspected. It is a point of much nicety to determine when the fermentation has proceeded to such an extent as to loosen the wool from the pelt; for if it be allowed to proceed beyond that stage, the pelt itself would become injured.

When the fermentation is completed, generally in about five days, the skins are removed to a beam and there 'slimed,' that is, scraped on the flesh side to remove a slimy substance which exudes from the pores. The wool is then taken off, cleaned, and sold to the hatters for making the bodies of common hats. The stripped pelts are steeped in lime-water for about a week, to 'kill' the grease, and are next 'fleshed' on the beam. After being placed in a 'drench,' or solution of sour bran, for some days, to remove the lime and open the pores, the skins are alumed and subjected to nearly the same processes as the true kid-skins. These Mediterranean lamb-skins do not in general measure more than about twenty inches by twelve; and each one furnishes leather for two pairs of small gloves. These kinds of leather generally leave the leather-dresser in a white state; but undergo a process of dyeing, softening, 'striking,' &c., before being cut up into gloves.

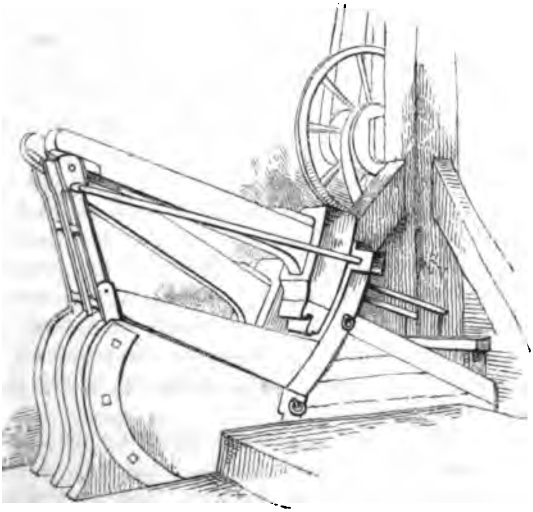
There are a few other kinds of skins prepared by aluming, but the general routine of processes is pretty much the same as herein described.

4. *Leather prepared with Oil.*—The 'killing' of the animal quality of skins (if we may use such an expression), whereby the skins are converted into leather, seems to consist in forcing out from the pores some albuminous substance, and replacing it with a substance of another kind. Thus, in tanning hides, the tannin penetrates into the substance of the skin and combines therewith; in sumaching, the larger portion of the sumach does the same thing; so do the alum, salt, egg, and meal in tawed leather; and lastly, so does the oil in the kind of leather now to be noticed.

That variety of leather called chamois, chammy, shammy, shammoy, shamoy, or shamoyed (for the name is spelt in all these different ways), which is the characteristic of oil-leathers generally, was originally a beautifully soft leather prepared from the skin of the chamois goat. A similar mode of manufacture is now adopted for sheep and other skins, but the name of chamois, modified in the spelling to a strange degree, is still applied to the leather produced. Mr. Aikin, in one of his lectures before the Society of Arts, made the following statement in reference to shamoyed leather:—"Till a few years ago, there was an immense quantity of the skins of sheep, goats, and deer shamoyed in England. Breeches of this article, either white or dyed, were commonly worn by persons whose occupations or amusements led them to be much on horseback. They were worn by most of the cavalry of Europe; and the English shamoyed leather being of extraordinary good quality, was employed in clothing, not only our troops, but the cavalry of Prussia, Austria, and most of the other German states. In the campaigns in Spain during the last war, it was discovered by the British commander that the health of the horse-soldiers was seriously affected in wet weather by the leather that they wore, which, fitting close to the skin and being long in drying, chilled the men and rendered them liable to rheumatism and other diseases. Woollen cloth was accordingly substituted; and the example having been followed by Austria and Prussia, this change has occasioned a great decline in that branch of the English leather-trade."

The shamoy leather, whether of the superior kind just alluded to, or of that more humble description known as 'wash-leather,' is prepared nearly as follows:—The deer and sheep skins undergo the earlier stages of preparation nearly in the same manner as for other kinds of leather, such as washing, liming, beaming, &c. It must be remarked, however, that the inferior or thinner kinds are generally made of split skins, the more irregular of the two halves, generally the flesh side, being used for this purpose; the other half being alumed or tawed for 'skiver' leather. In general, oil-leathers have the 'grain' surface of the skin entirely removed before any oil is applied; as this removal not only affords a much softer surface, but greatly increases the extensibility of the leather, which still remains sufficiently strong and elastic for the purposes to which it is applied. This 'frizing,' or removal of the grain, is effected either by the edge of a round knife or a rubber of pumice-stone.

The lime and other obstructions to the porosity of the skin having been removed by steeping in sour bran and water, the skins are wrung or pressed as dry as possible, and are then ready for the reception of the oil. This is forced into the pores in a curious manner. In one of the buildings of Messrs. Bevington's establishment are two pairs of 'fulling-stocks,' such as are represented in Fig. 8, and



Oil-Leather Fulling-Stocks.—Fig. 8.

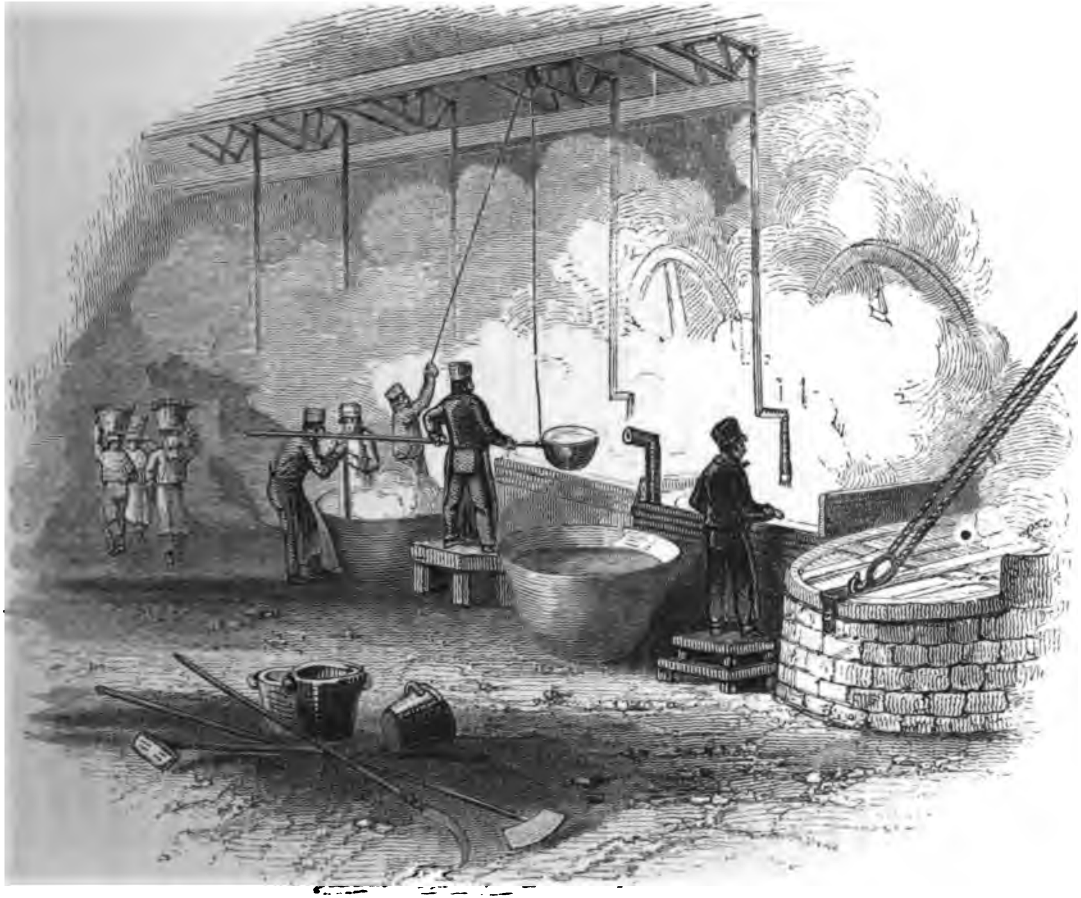
somewhat resembling those used in the woollen manufacture. Each pair consists of two stocks, which may be likened to heavy wooden hammers; the head, covered with copper, being attached to a long beam or handle lying in an inclined position. Near the lower end of each a wheel revolves, by which the hammer is in turn lifted up and let fall again, through a space of about a foot. The fulling-stocks work in a kind of trough, so that any substances which may be placed in the bottom of the trough receive a blow from each stock every time it descends. The upper or handle end of each stock is so adjusted as to work on a pivot or axis.

Into the trough connected with these fulling-stocks the leather is placed; the stocks are set in action; and the leather is beaten alternately by one and the other until rendered as dry as possible. Cod-oil is then poured on the skins in the fulling-machine, and this is forcibly driven into the pores of the skins by another lengthened beating with the stocks. The trough is so formed in an arc or curve, that as the stocks beat the skins, the latter become turned gradually over and over, whereby every part of each is exposed to the operation.

When the oil is beaten in, the skins are removed, shaken out flat, hung out in the air to dry, again put into the fulling-mill, supplied with fresh oil, and subjected to a renewed fulling with the stocks. Again and again is this repeated; oil being poured on the skins in small quantity, and then beaten into the pores by means of the stocks. This occurs as many as eight or nine times, oil being added each time, and well beaten in, until two or three gallons of oil have been imbibed by one hundred skins.

When the oil is thus forced into the heart of the skins, they are placed in large tubs, where they undergo a kind of fermenting process, by which a more intimate action of the oil upon the fibres seems to be induced. These tubs are placed in one of the lower buildings near the fulling-stocks; and from them the skins, now converted into shamoy leather, are removed, to be immersed in a weak solution of potash, as a means of removing whatever excess of oil may have remained in the leather. After being hung up to dry in the open air, the leather is finished.

Thus have we endeavoured to give an outline of a manufacture which is supposed to rank fourth in the kingdom, being only excelled in importance by those of cotton, wool, and iron. The quantity of hides and skins converted into leather yearly in England is almost incredibly large; at Messrs. Bevington's establishment alone there are about two hundred and fifty thousand skins annually converted into leather by the aluming or tawing process, two hundred and twenty thousand by the sumach-tanning process, as well as a small number by the oil-dressing process. This circumstance marks the importance and extent of the leather-manufacture, respecting which Dr. Campbell, in his 'Political State of Great Britain,' makes the following apposite remark:—"If we look abroad on the instruments of husbandry, on the implements used in most mechanic trades, on the structure of a multitude of engines and machines; or if we contemplate at home the necessary parts of our clothing—shoes, boots, and gloves—or the furniture of our houses, the books on our shelves, the harness of our horses, and even the substance of our carriages,—what do we see but instances of human industry exerted upon leather? What an aptitude has this single material in a variety of circumstances for the relief of our necessities, and supplying conveniences in every state and stage of life? Without it, or even without it in the plenty we have it, to what difficulties should we be exposed!"



IX.—Soap-Boiling Coppers.—Face p. 187.

IX.—A DAY AT A SOAP AND CANDLE FACTORY.

If the reader will ramble some fine morning to that little green oasis in the great world of London—the Temple Gardens, and glance across the river, he will see immediately opposite to him a tall, black, bulky chimney, distinguishable from those which surround it by its large dimensions, and sending up its contribution to the smoky atmosphere of the metropolis. This chimney, and the buildings with which it is connected, point out the spot to which our attention will be next directed. It is true, the buildings present few of those attractions pertaining to "river scenery," nor do they add much to the famed beauties of the "banks of the Thames;" but they furnish an indication—one among many—of the commercial features of the metropolis, which are by no means devoid of interest.

We must quit the Temple Gardens, and cross Blackfriars Bridge to the Surrey side of the water, in order to reach the spot in question. The "way to wealth" in London is generally through some narrow, dirty, dark, and crowded street, bounded on either side by ranges of factories, warehouses, or wharfs; with waggons and porters and cranes and bales of goods meeting the eye at every few steps. A street called Upper Ground Street, leading westward from Blackfriars Road at a short distance from the river, although it may not have a distinguished character as a "way to wealth," is certainly both narrow and dirty, and leads to many large factories and warehouses, most of which are situated in a part of the line called the Commercial Road, forming the communication between Upper Ground Street and the Waterloo Bridge Road. Among these factories on the northern side of the Commercial Road, and occupying the space between it and the river, is the one to which our attention will be here directed, viz. the Soap-Works of Messrs. Hawes.

This factory occupies the site where Queen Elizabeth's Barge-House formerly stood; a building wherein the state barge of those times appears to have been kept, and to have undergone the necessary repairs.

A creek or dock of some kind or other existed, into which the state barge was brought, but of which no vestiges now remain. A narrow pathway or passage leads down on the eastern side of the factory to the water's edge, and is known as 'Old Barge-House Stairs.' In the old maps of London, the 'Old Barge-House' is indicated as existing on this spot; but about a century ago the house ceased to be named, and we then find 'Old Barge-House Stairs' indicated. After the barge-house was removed, a glass-factory was established here; but about seventy or eighty years since the manufacture of soap was commenced at this spot.

On entering the outer gates of the factory, we find ourselves in an open court, with a dwelling-house immediately on the left, a range of low buildings on the right, a counting-house and offices nearly in front, and adjacent to the latter the entrance to the main buildings of the factory. In the open court may generally be seen waggons and carts, laden either with the raw materials from whence soap and candles are to be made, or with the manufactured articles about to leave the premises. Of the offices and counting-house we need say nothing; they contain the usual arrangements for the partners and clerks in the establishment. Contiguous to these offices is a small laboratory fitted up with a furnace, a sand-bath, a distilling apparatus, and other conveniences for conducting the chemical analysis of soap, and for making experiments incidental to the manufacture. The manufacture of soap is conducted in the warehouses westward and northward of the offices; the candle department eastward; and we will glance first through the former, and afterwards through the latter.

The building in which the main operations of the soap manufacture are carried on, and which is represented in our frontispiece, covers a large area of ground, and is nearly filled with coppers and vessels of considerable dimensions. It is technically known in the factory as the 'Copper-side;' but we shall perhaps be better understood if we term it the 'boiling-house.' As we pass along the central avenue of this building from south to north, we have on the right hand a range of coppers or boilers, nearly a dozen in number, and averaging about eight or ten feet in diameter, the height being between four and five. These coppers are filled with soap or the materials for its formation, in various stages of progress. In one the soap is nearly in a finished state, and is about to be removed; in another, the ingredients are boiling, and sending up a profuse volume of steam; into a third a supply of alkaline liquor is being conducted, from vats wherein it is prepared; from a fourth the spent ley or liquor is being pumped, after having imparted its alkaline property to the soap; some are for 'mottled' soap, some for 'yellow,' some for 'white' or 'curd' soap. According to the time when the 'boiling-house' is visited, so will these operations vary, but in general the contents of the coppers show the soap in many different degrees of formation. These coppers, as in many other instances, are oddly termed, for they are in reality iron vessels surrounded with brick. No flues or fires of any kind are connected with them; the boilers being heated by steam, constantly passing from a large boiler which supplies all these vessels, and which is situated in another part of the factory. The introduction of the method of heating by steam instead of fire, in soap-factories, sugar-refineries, and other establishments, is one of the most important improvements of modern times; economizing space and fuel, maintaining an equable temperature, and lessening the liability to accidents by fire. In each copper is a pump, for removing the spent ley at a particular period in the process.

Along the left hand of the avenue, through the boiling-house and opposite the boilers, is a row of alkali vats, in which the alkali is brought into a purified and liquid state. The alkali employed in soap-making, and which is a crude carbonate of soda or of potash, is brought to the factory as a dry greyish powder; but before it can be used in the manufacture, the carbonic acid must be removed from the alkali, leaving the latter in a caustic state. This we shall explain further on; but we here merely observe, that the vats in which this purification takes place are situated a few feet to the left of the boiling-coppers, and that a shoot or trough conducts the liquid alkali from the vats to the coppers.

Adjoining the boiling-house on the left is a passage leading down to the river, through which is conveyed the carbonate of lime resulting from the purification of the alkalis, a residuum which is extensively used as a manure on stiff lands, and of which a considerable quantity has been shipped to the West Indies since the abolition of slavery. Its beneficial effect is much increased by the small quantity of alkali and salt which it contains; and very interesting accounts have been published at various times, exhibiting the effect of this manure on particular plants. On the right of the boiling-house, and communicating with it by a door, is the 'frame-room,' to which the soap is conveyed after being made; the name of *frame* being given to the vessel receptacle into which the made soap is poured, and in which it remai till cold. The frame-room is full of these receptacles, nearly a hu dred and fifty in number, lying in ranks or rows side by side, and t rows opposite each other. In walking between these rows of frame we see in one place a man filling a frame with liquid soap; in anothe men taking a frame to pieces after the solidifying of the soap; in third, other men cutting up a mass of hardened soap into slabs.

Near the frame-room is a range of ware-rooms, in which the slabs soap are cut up into bars, and then piled up in tiers, like bricks in wall. If "cleanliness is next to godliness," according to the old adag we ought to have very pleasant thoughts while passing between the walls of soap—here 'mottled'—there 'yellow'—in another p 'curd,' and so on; but the truth is, that the odour from such a m of soap, and the unavoidable absence of cleanliness in the manufactu somewhat disturb the pleasure of contemplating the ulterior purp to which the soap is to be applied.

In other parts of the factory are placed the boiling-house for so soap, and warehouses connected with it. The soft-soap copper heated and managed in the same manner as the coppers for the ha soaps, and holds fourteen or fifteen thousand pounds of soap. As t kind of soap is not of such consistence as to enable it to be cut in slabs or bars, it is packed in barrels and sent from the factory in pasty or semi-fluid state. In connection with this part of the facto too, are six or eight vats for decarbonizing and purifying the carb nate of potash used as the alkali for soft soap. Some factories a built on such a regular plan, that the visitor retains a clear notion the relative positions of the several parts; but in the present case t connecting doors, passages, and stories, between one part of the facto and another, are so tortuous and perplexing, that we cannot be p perly topographical in our details. We can only say, therefore, in r spect of other parts of the soap department, that in one place is a sto room or warehouse for tallow; in another, a similar depository for kalis; in a third, for resin (an important ingredient in yellow soap in a fourth, for oil; in another for 'kitchen-stuff,' an ingredient the commoner kinds of soap. There is one room in which barrels palm-oil are kept, and in which the oil—solid in our climate—is melt out of the cask through the bung-hole by means of steam. In anoth spot the oil thus melted is purified and bleached, and brought int state fit for the soap manufacture. Other rooms, or portions of rooms, are devoted to various subsidiary processes relating to the soap manufacture, but to which no particular notice need here be paid.

After having visited the various portions of the soap department, we glanced through the candle department, which, although much less considerable in size, presents many ingenious arrangements and many curious applications of the division of labour. The principal room in this department is that in which the 'dip' or 'store' candles are made, and which we may perhaps term the 'dipping-room.' This is, to the eye of a stranger, the most singular-looking room in the factory. It is of considerable height, having two stories or floors, one extending over the bottom in the usual way, and the other forming a kind of gallery round the four sides, at the height of about twelve feet from the floor. An inclined plane leads down from the gallery at one end to the floor at the other, consisting of a platform with ledges of wood at distances of about a foot asunder, forming a kind of an apology for a flight of stairs: it is, indeed, a kind of staircase, such as is used by ship-builders to ascend the sides of a ship, and is adapted by the smallness of its angle of elevation for the ascent of persons carrying loads. The floor or ground of the room is devoted to the manufacture of the candles, and the gallery to some subsequent operations. Along the middle of the floor is a row of cisterns, filled with tallow in a hot and melted state, which is kept at a proper temperature. Around the room on all four sides, and distant a few feet from the cisterns, are reservoirs or vessels of melted tallow, filled from the central cisterns, and consumed in the process of making candles. Between and above are candles, or the skeletons of candles, hanging in thousands—some having had only a single garment of tallow to cover the nakedness of the wicks; some more plentifully coated; and some nearly in a finished state. On three sides of the room men are making candles by the aid of the machines which we shall speak of by and by; while in other parts of the room other men are 'dipping' according to the method in use before the invention of the machines. In one place a man is replenishing the supply of hot tallow in his dipping cistern, from the cisterns in the middle of the room; in another, is a boy removing the made candles from the machines, and fitting on a new supply of wicks; while other men and boys are busied in various parts of the manufacture.

On ascending the inclined plane to the gallery, we see near the outer edge of the gallery candles hanging on sticks; and round the gallery,

next the wall, are a series of work-benches, or tables, at each of whi
a man and a boy are engaged, the one to weigh the candles, accordir
as they are 'eights,' 'tens,' 'twelves,' &c.,—denominations too we
known to need explanation; and the other to fasten the candles on
string. In a small room attached to the candle department is kept tl
store of rushes for making rushlights: they are gathered in Lancashir
and are brought to town in bundles weighing a few pounds each.
another room are sacks or bags filled with cotton, wound up in bal
of about three pounds weight. There is also a beautiful machine,
which a man is engaged in making wicks for 'mould' and 'dip' ca
dles. A third room, larger than those just alluded to, is the 'moul
room,' in which the mould candles are made by the aid of an elabora
and ingenious machine. Connected with the candle department, als
are the requisite stores and warerooms for the commercial arrang
ments of the establishment.

Besides the various buildings and rooms belonging particularly
the soap or candle departments of the factory, there are mechani
and other arrangements of a general kind, which need not much d
scription. In convenient parts of the factory are two steam-engines
different horse-power. Near these is a blacksmith's shop, for the
pair and adjustment of various kinds of iron-work used in the facto
The smoke from the different flues and furnaces is conducted int
square or rather pyramidal chimney of large dimensions. A carpe
ter's shop furnishes the conveniences for making packing-cases, box
&c. for the commercial department. Lastly, and perhaps to the man
facturers the least pleasant of all—there are rooms and offices fitted
for the Excise-officers, one or more of whom are in the factory d
and night.

It is a great blot upon the fiscal arrangements of this country, a
one which seriously affects the manufacture of malt, of glass, of so
and many other articles, that in order to collect the duties levied
these commodities, the officers of the Excise are empowered to contr
as it were, every step of the processes, and to regulate the extent
which any improvement in the operations may be carried. It is
the amount of duty collected to which we here refer; this is anoth
subject: it is the mode of collection which is so objectionable, by i
posing impolitic checks to the natural course of improvement in n
nufacturing processes. Considerable ameliorations have, within
recent period, been made in the mode of collecting the revenue, a

the survey of the premises of soap manufacturers; and it is probable that by degrees every facility consistent with the security of the revenue will be afforded for the introduction of improvements and the protection of the fair trader.

While on this point, there are a few facts which may be adverted to respecting the effects of imposts of this kind. The fair trader is doubly injured by them: he is injured by the reduction he is obliged to submit to in the price of his commodity, in consequence of the competition with the smuggler; and almost to a greater degree from the restrictions which are necessarily imposed upon him for the protection of the revenue. These oblige him to manufacture, not according to his judgment, but as directed by law; the ignorant and intelligent are thus placed upon the same footing, and the dishonest or fraudulent trader is in a more advantageous position than either. The success which has attended the reduction of the duty on soap from 28*l.* to 14*l.* 14*s.* per ton proves the truth of these observations; and could this amount be further reduced, it is probable that in a short time, by lessening fraud and increasing consumption, a larger revenue would be produced. The quantity of soap charged with duty for *home consumption* had been decreasing from 1828 to 1832, the year preceding the reduction, when the duty was charged upon 91,000,000 lbs. In 1834, the year after the reduction, it increased to 104,796,000 lbs., showing an increase of 14 per cent. in two years. It has since gradually increased to 127,000,000 lbs. in 1840. This quantity, however, it is believed, does not indicate accurately the total quantity made. The population of Great Britain is now 18,540,000. The most accurate calculations prove that the consumption of soap in the families of artisans earning from twenty to thirty shillings per week is 10 lbs. per head per annum, and in families above this class from 12 lbs. to 25 lbs. per head. Now, the quantity used per head in 1840 was 6½ lbs., a smaller quantity than is used in workhouses or prisons, or than is allowed to soldiers; but if half only of the population are in such circumstances as to use the quantity ascertained, by very extended inquiry, to be used by artisans, and making no allowance for the extra quantity used by the other classes, we are driven to the conclusion either that nearly one-half of our population use no soap, or that a very large quantity is made and not charged with duty. Many facts of this kind are engaging the attention of the Excise, with a view to the introduction of improvements into the system.

There is a curious account of this trade in a small pamphlet, printe for Nicholas Bourne, in 1641, entitled 'A Short and True Narrativ concerning the Soap Business.' It contains an account of a paten granted to a Company for the exclusive manufacture of soap, unde the title of the 'Governor, Assistants, and Fellows of the Society o Soapmakers of Westminster' (1622), on condition of their paying t his Majesty 4*l.* per ton on 5000 tons annually. The manufacturers o that day (twenty in number) refused to join and acknowledge thi Company; whereupon the Company obtained a proclamation forbidding, amongst other things, the sale of soap which had not been assaye by the Company. An information was then exhibited in the Sta Chamber (1633) against sixteen London makers for opposing and affronting the letters patent; to which the defendants pleaded and demurred, &c., and after much discussion (all the defendants havin been committed to prison for having put in their answer one day to late) the judges certified "all the answer except the first four word and last ten as fit to be expunged;" and it was decreed that the defendants be imprisoned during his Majesty's pleasure, and fined in various sums from 1500*l.* to 500*l.* All were sent to prison. Fourteen remained there for forty weeks, and two died in prison. These tyrannical acts were followed by various proclamations and orders in counc restricting the manufacture of soap except by the patentees, and fixin the price at which soap should be sold, and the materials from whic it should be made. In 1635 many other soapmakers were committe to prison, and greater power was given by proclamation to the patentees upon their covenanting to pay 6*l.* per ton on 5000 tons annuall In a short time, however, the patentees, having "vexed the whol kingdom with their soap for three years," obtained a warrant from h Majesty (1637) for 40,000*l.* for giving up the patent, and 3000*l.* f their houses, and obliged the soapmakers of London to pay the 20,000*l.* for their materials, so that they might have use of their trac again, of which they had been deprived. Little is known of the trac from this time to 1704, when Queen Anne imposed the first Exci duty. Several pamphlets and statements, on half sheets, are to b found in the British Museum, containing petitions to be relieved fro taxes, &c., but there is no account of the quantity manufactured.

But we must quit statistics, and return to the factory. Having noticed the arrangement of coppers, boilers, engines, frames, mould cisterns, pumps, &c., it may be well to give a brief sketch of the oper tions conducted therein, and of the steps by which certain raw materials are converted into the well-known forms of soap and candles. Strictly speaking, there is a great deal of chemical nicety involved in the manufacture, both in theory and practice; but this is not the place where such matters can be consistently treated in a scientific manner.

Soap is designated in the 'Penny Cyclopædia' as a compound derived from the union between fat or oily substances and alkalis; and the nature of its formation is expressed in the following terms:—"It has been found by Chevreul that different varieties of fatty matter consist chiefly of two parts: one hard, to which he gave the name of stearin; and the other soft, which he termed olein. He also discovered that stearin is composed of stearic acid, and a peculiar principle, which, on account of its sweet taste, he named glycerin. When, in the manufacture of soap, an alkali (soda, for example) is heated with tallow, the soda gradually dislodges the glycerin from combination with the stearic and oleic acids, and by combining with them, forms soap, or, in other words, a compound of stearate and oleate of soda, and the glycerin remains in solution." That the manufacture of this substance from the two classes of ingredients here mentioned has been long known is sufficiently indicated by a circumstance mentioned by Mr. Parkes in his 'Chemical Essays:'—"On examining the excavations that were made on the spot where this famous city (Pompeii) formerly stood, a complete soap-boiler's shop was discovered, with soap in it, which had evidently been made by the combination of oil and alkali. This soap was still perfect, though it had been manufactured more than seventeen hundred years."

As there are many kinds of fat and oil, and two very distinct kinds of alkali employed, it naturally follows that the soap will possess different qualities, and present different appearances, according to the ingredients.

Mottled soap is made from tallow, soda, a little 'kitchen-stuff,' a minute quantity of salt, and water. Its analysis is—alkali, 6·5; grease, 62·5; water, 31·0: total, 100. The tallow principally employed in the soap factories of England is brought from Russia, and is exported from thence in a solid state in barrels. So large a quantity of this substance is used in England, that about thirteen hundred thousand cwts. are imported every year, yielding to the revenue somewhere about two hundred thousand pounds sterling. This supply is obtained principally from Russia, five-sevenths of whose exported tallow are sent to England. The tallow arrives in this country in a tolerably pure state, and requires no preparation previous to its employment in making soap. The heterogeneous substance known to domestic servants and 'dealers in marine stores' by the name of *kitchen-stuff*, although very impure, is capable of being cleansed and refined, and used in the same manner and for the same purposes as tallow: it is heated in a copper, strained, and otherwise freed from the extraneous substances which are mingled with the tallow. It is only in the coarser kinds of soap that this material is used.

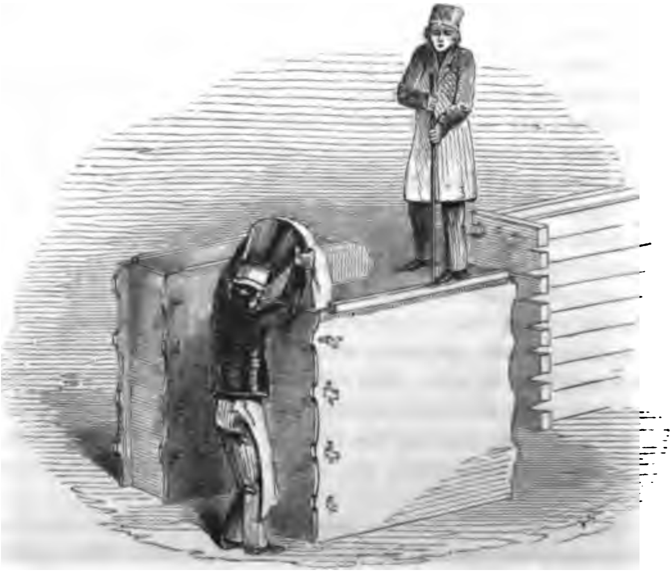
The alkali used for mottled soap is soda, the gradual changes in the production of which form a curious episode in the history of the soap manufacture. Although the form in which the alkali is used by the manufacturer is that of caustic soda, almost or entirely free from any acids, yet the state in which it is sold is that of a carbonate, more or less mingled with impurities. Barilla and kelp were until lately the only sources from which this alkali was derived; the one of foreign production, and the other British. Barilla is a kind of ash obtained by burning a South European plant called the *Salsola soda*, which plant is cultivated with great care by the Spaniards and the Italians. A few years since there were 6000 tons imported annually from Spain, Sicily, and Sardinia; and formerly the quantity was much greater.

Kelp, another form of the carbonate of soda, alluded to above, is the ash remaining after the burning of sea-weed, and was introduced into the London market for the use of the soap trade by Mr. Hawes, the father of the present proprietors of these works. It contains only a little of the alkaline salt, but a large quantity of common salt, some salts of potash, and other substances. Previous to the year 1822, a duty of eleven or twelve shillings per cwt. being laid on barilla, a considerable quantity of kelp was made on the coasts of Ireland; and about a century ago from the present time the manufacture was begun in Scotland, where, in consequence, the land in certain localities by the sea-shore became greatly advanced in value, very large annual revenues being derived from estates which had previously been wholly unproductive. Dr. M'Culloch gives a graphic account of the kelp manufacture in its most flourishing state:—"The kelp season had now commenced, and the whole shore was one continued line of fires the grey smoke streaming away from each on the surface of the water till, mixing with the breeze, it diffused its odoriferous haze over all the surrounding atmosphere. . . The weeds, being cut by the sickle at low water, are brought on shore by a very simple and ingenious pro cess. A rope of heath or birch is laid beyond them, and the ends being carried up beyond the high-water mark, the whole floats as the tide rises, and thus, by shortening the ropes, is compelled to settle above the wash of the sea, whence it is conveyed to dry land on horseback. The more quickly it is dried the better the produce; and when dry it is burned in coffers, generally constructed with stone, sometimes merely excavated in the earth. In Orkney the latter are preferred. As twenty-four tons of weed at a medium are required to form a ton of kelp, it is easy to conceive the labour employed for this quantity in the several processes of cutting, landing, carrying, drying, stacking, and burning."

How strangely do variations in one branch of commerce affect the arrangements of another! Twenty years ago common table-salt was sold at four or five pence per pound; but when the duty was wholly removed, this price fell to one halfpenny. Manufacturers immediately turned their attention to this substance, as a source whence saleable commodities might be produced. Common salt is formed of chlorine and sodium, and by chemical agency the two can be separated, and each one made to combine with some other substance. Such has been the case in respect to the soda used in the soap-manufacture: by far the greater part of it is produced from the sodium which forms one of the ingredients in common salt, the decomposition of which in sufficient quantities to supply the soap and glass makers has for some years employed large capitals and many hundreds of workmen. This alkali, or 'white ash,' as it is called, made from salt, has driven kelp and barilla out of use. It is produced by treating common salt in a peculiar manner with sulphuric acid, from which there result muriatic acid and sulphate of soda: this sulphate is converted into a carbonate of soda by contact with carbon; and, lastly, the carbonic acid is driven from the carbonate, leaving the soda in a caustic state, and forming, when in solution with water, the liquor which soapmakers call a ley or lye.

The ley is pumped out of the vats into the boilers, where it is mixed with the requisite quantity of tallow, and any other fatty substance which may be employed. The mixture is then heated by steam, and well boiled, an attendant stirring the mass occasionally. After a time the tallow is found to have combined with a portion of the ley, including all the alkali, and the remaining or spent ley is then of no further use in the process. It is pumped up from beneath the soap by a pump whose barrel descends to the bottom of the copper; and fresh supply of ley is introduced. Again and again is this process r peated, new leys being introduced after the spent liquor is withdraw and the leys being used in a stronger or more alkaline state as tl process advances towards completion. When the soap is near finished, that peculiar appearance to which it owes the name 'mottled' soap is given to it by sprinkling upon the surface a sm quantity of very dense and strong ley: this percolates slowly throu the mass of soap, and leaves in its track those dark-coloured vei which constitute mottling.

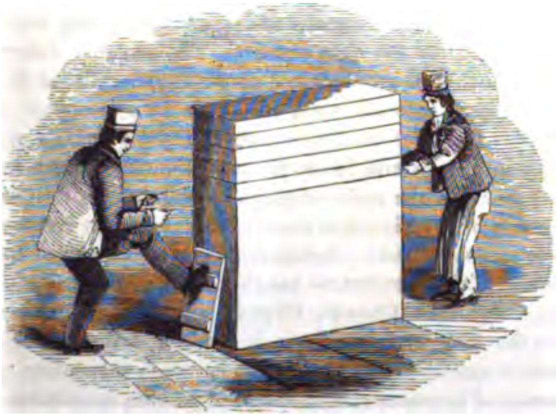
When the tallow and alkali have completely formed into soap, a have attained a proper consistency, the soap is laded from the coppe in buckets or pails, and conveyed to the frame-room, where it poured into the 'frames.' These frames have, until within the l



Filling Soap-frames.—Fig. 2.

few years, been made wholly of wood, but cast-iron frames are n occasionally used. The wooden frame is a kind of well or cister formed of a pile or heap of frames laid one on another. Each sep rate part consists of a rectangle of four bars of wood, measuring internally forty-five inches by fifteen; and these rectangles are laid one upon another to a height of ten or twelve feet. The bars of the rectangles are so neatly squared and smoothed as to fit closely one upon another. The mottled soap is poured into these frames until full, and the reallowed to remain till cold, which occupies more or less time, according to the state of the weather.

When the mass of soap is cold and solidified, some iron fastenings, with which the rectangles of the frame were firmly bound together, are loosened, and the rectangles removed one by one, each one being lifted off the mass of soap. The soap is then presented to view as a compact body, whose dimensions are those of the interior cavity of the frame. Some of these masses of soap weigh three or four thousand pounds each. The next process is to cut the mass into slabs or slices about three inches in thickness. To effect this a man marks the surface of the soap with parallel lines, by means of sharp points, inserted in a gauge-stick; and two men draw a piece of wire through the soap in the direction of each mark, one man holding the wire by handles at the ends, and the other guiding the wire to the proper marks. The slabs are next taken to a machine in the form of a hollow box open at the top, with vertical crevices passing from the top nearly to the bottom of two opposite sides. The slabs being ranged horizontally in



Cutting Soap.—Fig. 3.

this box, a piece of wire is passed down each of the crevices in succe sion, cutting through the slabs in its progress. As the crevices a about three inches apart, it follows that the slabs are cut into ba about three inches wide and the same in depth, the length being abo fifteen inches. These are the bars in which soap is sold in the sho After the cutting, the bars of soap are piled one upon another in t form of a wall, and kept in that state for a certain time until requir to be removed from the factory.

For curd or white soap the same general description will suffice applies to mottled, with some minor exceptions. As its whiteness one of its chief characteristics, the tallow is selected with more ca and no ingredients are introduced which will be liable to deteriora the colour. The process of mottling is in this case dispensed wit but the general outline of processes, such as the decarbonizing of t alkali, the melting and boiling of the ingredients, the framing, t cutting, &c., is much the same as in the manufacture of mottled soa

Yellow soap is less expensive than white or mottled; and it ow this cheapness, as well as its colour, and certain properties which possesses, to the large employment of palm-oil and resin in its comp sition. Although resin is in appearance very different from tallow, y it possesses the same property of melting and combining with an alka and forming a soap by the combination. The analysis differs little pure soap from that of mottled, and consists generally of 6 alkali, grease, 32 water. Inferior soap, although in appearance nearly t same, contains from 10 to 20 per cent. more water—a fact whic if generally known, would lessen the attractions of "cheap soap." T nature and source of the resin employed are simply as follows:—Fr several species of the pine-tree there exudes, when an incision is ma a grey-coloured semi-fluid substance, known in commerce by the na of turpentine. This turpentine has the distinctive names of Veni Strasburg, Carpathian, Canada, Cyprus, and common turpentine, cording to the countries whence it is brought, and the species of pi from which it exudes. By distillation common turpentine yields t oil or essence of turpentine, and the solid residue constitutes resin.

Palm-oil is obtained from the oil-palm of Guinea, cultivated in t western parts of Africa. The fruit of this tree is ovoid, about the si of a pigeon's egg, with its outer fleshy covering of a golden yell colour. The oil is obtained by bruising the fleshy part of the fru and subjecting the bruised paste to boiling water in wooden morta an oil of an orange-yellow colour separates, which concretes, when cool, to the consistence of butter, and has, when fresh, the smell of violets, and a slightly sweetish taste. The Africans use this oil in cookery, and for anointing the body; but when imported into England it is used in soap-making, in perfumery, and in medicine, for which purposes two or three hundred thousand cwts. are used annually. When brought to the soap-factory it is in casks in a solid state, and the mode adopted for extracting it is to place the cask over a trough with its bunghole downwards, and to pass a steam-pipe into the cask, by which means the palm-oil is brought to a liquid state and made to flow out of the cask. The oil is afterwards conveyed to a vat, where it is bleached by a chemical process. The use of this oil in soap, or wherever it can be introduced, is a matter of almost as much importance to the philanthropist and the statesman as to the soap-manufacturer. The latter looks at it merely as a good and cheap ingredient; the philanthropist may view it in respect to its African origin, as a powerful instrument in the abolition of the traffic in slaves; the statesman may feel that it secures to our manufacturers a lucrative barter trade, free from the fiscal regulations which impede our commerce with old states. Every cargo of palm-oil bought with our manufactures will tend to introduce among the Africans a taste for traffic free from the horrors of human barter.

The mode of preparing the alkali for yellow soap, the process of melting and boiling it with the tallow and resin, and the general routine of manufacture, differ but little from those relating to mottled soap. The frames used are, however, very different. They are made of five pieces of cast-iron: one for the bottom, two for the sides, and two for the ends. By a simple mode of fastening at the edges, the whole can be quickly put together, so as to form a sort of well or cistern, between four and five feet high, forty-five inches long, and fifteen wide. Into these frames the yellow soap is poured, the contents of each being about fifteen cwt. These frames are not only put together and taken to pieces with more ease than the wooden frames, but the iron being a good conductor of heat, the process of cooling is effected more rapidly. The cutting of yellow soap into slabs and bars is effected in the same way as that of mottled.

Soft soap, a commodity which is almost exclusively used in the woollen manufacture, differs considerably from hard soap in its ingredients, its consistence, and its general appearance. Both the alkaline and the oleaginous ingredients are different from those employed hard soaps; since potash is employed instead of soda, and oils are m largely used than tallow. This soap, when of good quality, cons of alkali 9, oil and tallow 42, water 49; total, 100. The potash ployed in the soap manufacture is brought principally from Canada the United States. The carbonate of potash is rendered caustic, that free from carbonic acid, by a process similar to that adopted for soda alkali; and several of the vats in the soap factory are emplo for this purpose.

The oils employed in soft soap, whether whale, seal, olive, or seed, are procured in the usual way, from the blubber of the former, the fruit of the third, and the seed of the fourth, and nee particular description. Nor does the mode of combining the ingr ents to form this kind of soap require any lengthened notice. It n however, be remarked, that instead of supplying successive portion alkaline ley to the boiler, and pumping out the spent ley at interv the whole of the ley is supplied at once, and kept boiling with the and tallow until the soap is made. The use of the tallow employe to give consistency to the oil soap, the general quality of which is dicated by the gradual formation of white specks throughout the s which arise from the combination of the tallow with the salts of pot Soft soap, as its name imports, has a consistence which renders use the processes of framing and cutting: it is placed in barrels or ca when finished, and in that state sent from the factory.

With respect to the large variety of soaps known as 'toilet,' 'fan or 'perfumed' soaps, little need be said here. They are gener made from good white soap, which is remelted and modified in its f and appearance by perfumes and other substances. None of t fancy soaps are made at these works; they are either the produc of persons who devote their attention principally to the manufact or else of perfumers, who apply the fanciful terms—'soap à la r 'soap au bouquet,' 'cinnamon soap,' 'Windsor soap,' 'musk so 'almond soap,' &c., to their manufactures.

CANDLE-MAKING.

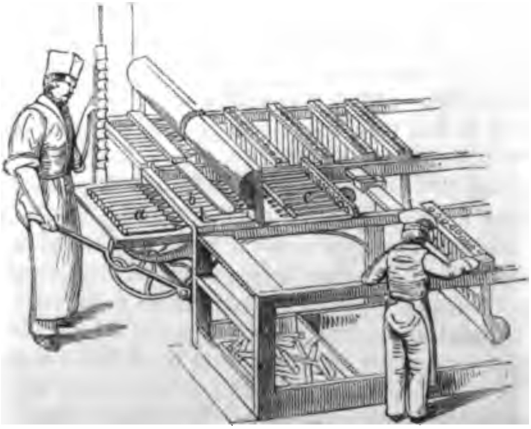
Let us now turn our attention to the processes of a branch of exceedingly simple and free from technical difficulties.

Candles can be made from any fatty substance which, at ordi temperatures, is in a solid state: wax, spermaceti, and tallow b the usual substances employed. That very essential part of a candle—the wick—performs an office which involves a scrap of philosophy not always well understood. The wick is composed of a dozen or more fibres of soft cotton, ranged side by side, and having just sufficient twist given to them to make them cling together. The threads are not so close together but that oil, or tallow, in a melted state, will ascend between them, by virtue of that capillary attraction which will cause a piece of loaf-sugar to become wet throughout if placed on a wet spot. When a candle is lighted the heat melts the upper part of the tallow, which then ascends between the fibres of the wick, and furnishes minute streams of combustible matter as fast as the oxygen of the air will consume it in the form of flame. The current of air constantly supplying oxygen to the flame, also performs an important duty: by keeping the outer surface of the tallow cool, it causes the formation of the 'cup' which contains the melted tallow that otherwise would run down and disfigure the candle, and render it unfit for use. The tallow, then, is the combustible matter, and the wick is the series of little tubes through which it ascends to the flame.

Wax-candles are not made at the factory to which our attention is directed, but a word or two may be said as to their manufacture. The wicks being cut and twisted, a set of them is suspended over a basin or vessel of melted wax, which is taken up by a large ladle and poured from time to time on the tops of the wicks. The melted wax, as it flows downwards, adheres to and covers the wicks throughout their length. This is repeated until a sufficient weight of wax has been gathered upon each. After the candles are sufficiently cool, they are rolled upon a smooth table in order to give them a perfectly cylindrical form, and are then polished.

We have said that at Messrs. Hawes's factory there is a very ingenious machine for making mould candles. It is generally known that candles of this kind occupy a medium rank between wax and 'dip' candles, resembling the former in regularity of shape, and the latter in material. Usually mould-candles are made as follows:—From ten to sixteen cylindrical pewter moulds are placed together in a wooden frame, so that their upper ends terminate in a kind of trough common to the whole. The wicks are inserted and kept firmly in their proper places in the centre of each cylinder by strong wires. The frame being then placed with the trough uppermost, the moulds are filled with melted tallow, and are placed in the air to cool. The wires by which the wicks have been fixed are then withdrawn, the sup fluous tallow is removed from the trough, and the candles are pull out of the moulds.

In the machine for making mould-candles many features of an tirely different kind are introduced. The wick, instead of being off to the exact length required for each candle, is wound on a r in lengths of one hundred feet, of which there are as many as th are moulds. In a kind of case or frame are enclosed a certain numl of moulds, with a reel of cotton attached to each. A portion of cott is unwound from each reel, and made to pass through a mould, t lower end of which is only large enough to admit of the passage the wick, and is held in its place by a pair of forceps. The frame case is then brought under a kind of box or cistern, into which melt tallow of a fine and pure quality is poured. By turning a handle, t melted tallow is allowed to flow out of as many little holes as there moulds, and thus the moulds become filled. As the moulds fill, a m pulls the wick in each mould straight and uniform, by laying hold the lower end. When one set is filled, the frame which contains th is wheeled along a kind of railroad, and another is filled in a simil manner. As soon as the tallow has solidified, a workman disengag the forceps, and scrapes the superfluous material from the upper en

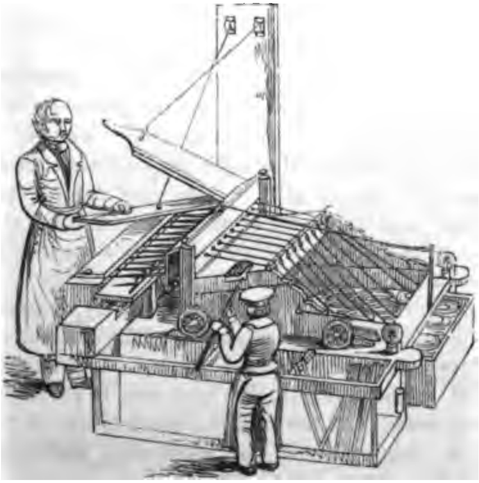


Morgan's Mould-Machine.—Fig. 4.

a, mould-candles; *b*, moulds, through which the candles are pushed by the rods, *c*.

of the moulds. The frame is then turned so as to bring the moulds into a horizontal position; and by a beautiful adaptation of machinery, the candles are forced out of the moulds and thrown on a table in parallel lines. The wicks in these candles are still connected with the coils of cotton wound round the little reels in the frames or cases; but the whole are severed in a few seconds by the attendant workman, when the candles are finished. All the mould-frames move along a double line of railroad, and the whole of the arrangements are so judiciously made that a man and a boy can manage the whole, and produce a surprising number of mould-candles in a short time.

The common 'dip' or 'store' candles are made, as most persons are aware, by dipping the wicks into a vessel containing melted tallow, a small coating of which adheres to the cotton fibres, as do likewise the subsequent coatings to that first laid on. The wicks are prepared at the factory in the following manner:—Balls of cotton, each weighing about three pounds, are procured from Manchester or the surrounding district, the cotton being previously made into a loose roving or cord, consisting of a dozen or more threads, slightly cohering. These cords (if we may so term them) are of different thicknesses, according to the size of the intended wick: the wick for those candles known as 'eights,'

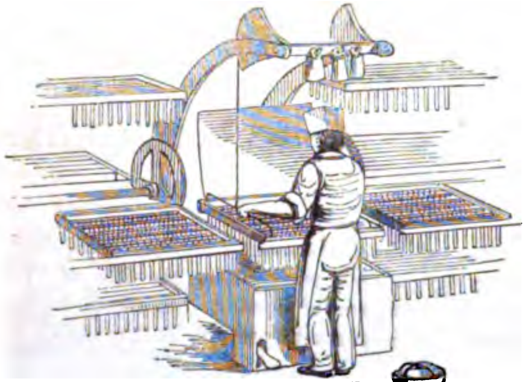


Machine for cutting the Wicks for Dip candles.—Fig. 5.

for example, containing thirteen cotton threads. A great number
these balls are carried to the wick-making machine, and put into a b
or drawer. A man takes the ends of all these balls, doubles a porti
of each cord round a broach or stick, and by a sharp blade (somewh
like that by which tobacco is shred) cuts all the cottons to the prop
length for wicks, giving to the whole of them, by the action of t
machine, a slight twist before he removes them. One stick-full
wicks being thus made, another is prepared in a similar manner; a
thus the preparation of wicks proceeds with great rapidity. By th
machine one man will prepare the wicks for fourteen or sixteen cand
makers. The wicks for some candles are twisted or spun in a par
cular manner, but this is effected at the cotton manufactory.

In making dip-candles by hand, a man takes three broaches or stick
each containing as many wicks as will suffice for about two pounds
candles, and holding them parallel and horizontal, dips the wicks in
a trough of melted tallow. This he does two or three times, and th
lightly draws the lower ends of the wicks over a sloping board, to
move the drainings of tallow. These three broaches are hung up
the tallow to dry and harden; another set are similarly treated, and
on. When the first dipping or 'lay' is dry, the coated wicks
dipped a second time; afterwards a third and a fourth; the numb
of repetitions depending on the size of the intended candles, and bei
about twelve for the candles known as 'twelves.'

By the machines now employed, however, the operations are grea
accelerated. At the time we witnessed the processes at the facto
one of the machines was employed in making 'twelves,' and was th
arranged:—Twenty-four candles were hung on each broach or stic
thirty broaches were ranged side by side, and formed an assembla
called a 'frame;' and thirty-six of these frames were attached to
suspended from the machine; so that the entire number of candles
tached to the machine amounted to nearly twenty-six thousand,
whole of which were made, by one man and a boy, between six o'clo
in the morning and four in the afternoon of the same day. In the fro
of each machine is a vessel of melted tallow, and the thirty-six 'fram
are so attached to the machine, that each can, in its turn, be broug
over the tallow vessel, and the candles dipped in it. A piece of ap
ratus, called a 'wiping-board,' is, after each dipping, ingeniou
brought down, by a lever moved by the foot, over the cistern;
ends of the candles are wiped on it, and the board rapidly re-ascen



Dipping-machine.—Fig. 6.

to its former position. There are two varieties of dipping-machines used at this factory, differing somewhat in the mechanical arrangement whereby the 'frames' are brought over the melted tallow, but similar in respect of the great saving in time and labour occasioned by their use. When the candles have been dipped a sufficient number of times (which is known by the use of a kind of steelyard or balance-weight indicating the total weight of all the candles on the machine), and are properly hardened, they are weighed up into pounds, and hung upon strings, the former by men, and the latter by boys, each of whom exhibits great dexterity and quickness in the operation.

Those long and slender candles known as 'rush-lights' differ only from common dip-candles in the material of which the wick is made. Instead of fibres of cotton, the wicks are made of dry rushes, which have a loop made at one end by piercing the rush with a sharp instrument, and are then cut to the required length by a gauge or knife. The dipping is conducted much in the same manner as for common candles, except that, from the comparatively small number required, the machine is not employed. Taking the 'moulds,' 'dips,' and 'rush-lights' together, there have been as many as twenty millions of candles made in this factory in one year.

X.—A DAY AT "DAY AND MARTIN'S."

Gay, the author of the well-known 'Fables,' published, somewhat above a century ago, a lively work under the title of 'Trivia, or the Art of Walking the Streets of London;' in which he thus addresses the "*shoe-blacks*," an important fraternity at that time:—

"Go, thrive: at some frequented corner stand;
This brush I give thee, grasp it in thy hand;
Temper the foot within this vase of oil,
And let the little tripod aid thy toil;
On this methinks I see the walking crew,
At thy request, support the miry shoe;
The foot grows black that was with dirt embrown'd,
And in thy pocket jingling halfpence sound.
The Goddess* plunges swift beneath the flood,
And dashes all around her showers of mud:
The youth straight chose his post; the labour ply'd
Where branching streets from Charing Cross divide;
His treble voice resounds along the Mews,
And Whitehall echoes—'Clean your Honour's Shoes!'"

One of the early numbers of Mr. Knight's 'London,' wherein the above lines are cited, thus records a modern revolution in the black-ball world:—"In one of the many courts on the north side of Fleet Street, might be seen, somewhere about the year 1820, the *last of the shoe-blacks*. One would think that he deemed himself dedicated to his profession by Nature, for he was a negro. At the earliest dawn he crept forth from his neighbouring lodging, and planted his tripod on the quiet pavement, where he patiently stood till noon was past. He was a short, large-headed son of Africa, subject, as it would appear, to considerable variations of spirits, alternating between depression and excitement, as the gains of the day presented to him the chance of having a few pence to recreate himself, beyond what he should carry

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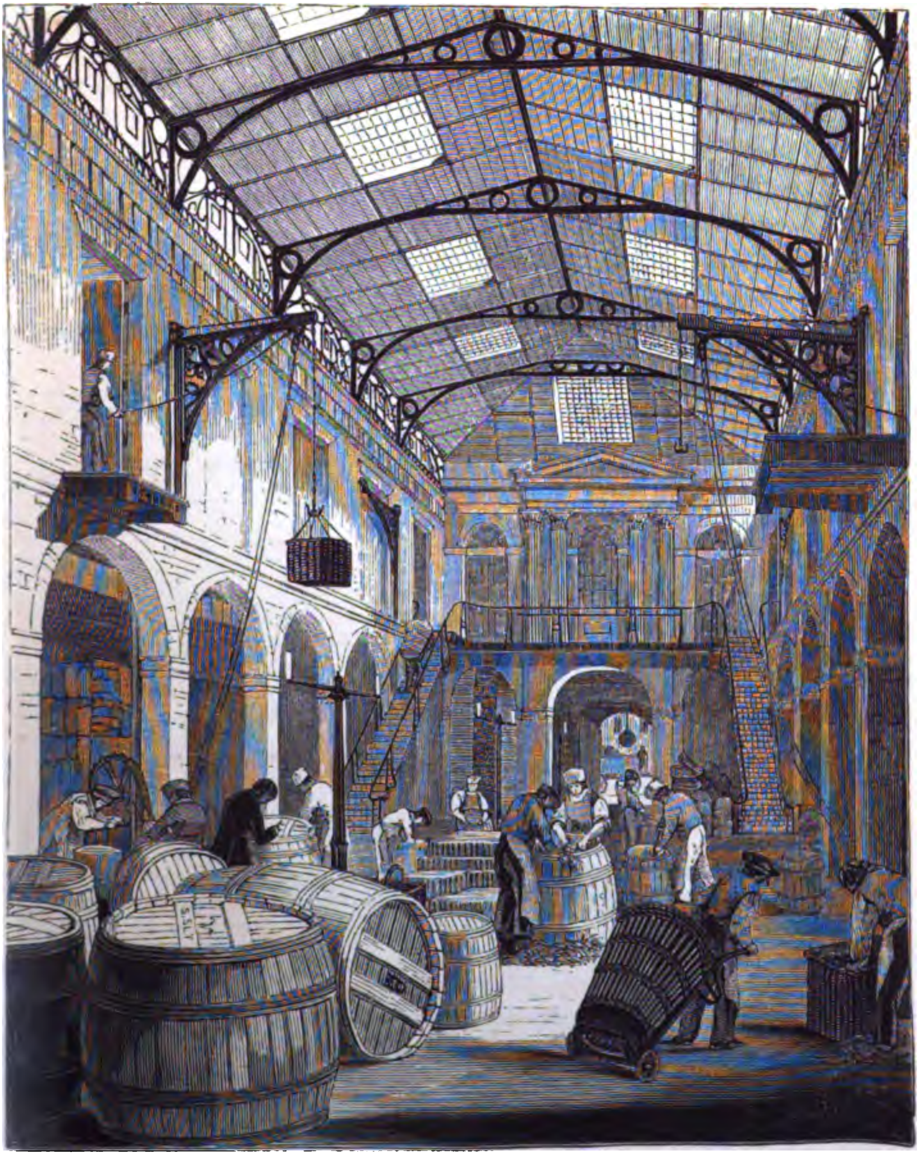
* Gay gives to the shoe-black a mythological descent from the Goddess of Mud.



X.—Packing Warehouse.—Day and Martin's Blacking Factory.—Face p. 208.

home to his wife and children. For he had a wife and children, this last representative of a falling trade; and two or three little woolly-headed *décrotteurs* nestled around him when he was idle, or assisted in taking off the roughest of the dirt when he had more than one client. He watched, with a melancholy eye, the gradual improvement of the streets; for during some twenty or thirty years he had beheld all the world combining to ruin him. He saw the foot-pavements widening; the large flag-stones carefully laid down; the loose and broken piece, which discharged a slushy shower on the unwary foot, instantly removed: he saw the kennels diligently cleansed, and the drains widened: he saw experiment upon experiment made in the repair of the carriage-way, and the holes, which were to him as the 'old familiar faces' which he loved, filled up with a haste that appeared quite unnecessary, if not insulting."

We may picture to ourselves an old gentleman of the last century, with his foot upon a stool, reaping the lustrous fruits of the shoe-black's labours, as a sequel to the cry of—"Clean your Honour's Shoes!" But (to quote from the same work),—"The cry is no more heard. The pavements of Whitehall are more evenly laid than the ancient marble courts of York Place, where Wolsey held his state, and Henry revelled; and they are far cleaner, even in the most

Shoe-black.—Fig. 2.

inauspicious weather, than the old floor beneath the rushes. Broad as the footways are, as the broadest of the entire original streets, the mightiest of paving-stones is not large enough for the comforts of the walker; and a pavement without a joint is sought for in the new concrete of asphaltum. Where the streets which run off from the great thoroughfares are narrow, the *trottoir* is widened at the expense of the carriage-road; and one cart only can pass at a time, so that we walk fearless of wheels. If we would cross a road, there is a public servant, ever assiduous, because the measure of his usefulness is that of his reward, who removes every particle of dirt from before our steps. No filth encumbers the kennels; no spout discharges the shower in a torrent from the house-top. We pass quietly onwards from the Horse Guards to the India House without being jostled off the curbstone, though we have no protecting posts to sustain us; and we perceive why the last of the shoe-blacks vanished from our view about the time when we first noticed his active brothers at every corner of Paris —a city then somewhat more filthy than the London of the days of Anne."*

But if this be so—if the streets be so incomparably cleaner now than they were a century ago (and no one can doubt it), what must become of the blacking-makers? The shoe-blacks of old became street-sweepers by degrees, from utter want of custom; and it might be feared that the vendors of the "incomparable jet"—the "easy-shining" composition which produces "the most brilliant lustre ever beheld," and will "keep good in any climate"—would likewise be driven to seek another source of employment. By no means. The blacking-makers are more important personages now than ever they were; they surprise us with magnificent buildings—more like mansions than factories—and with horses and waggons, travellers and agents, and all the commercial machinery incident to a large branch of manufacture. What sort of blacking the Londoners used a century ago, or who were the persons by whom it was made, we do not know; but if the streets are less miry now than they were then, and yet blacking be more generally used by all classes, we arrive at a sort of logical deduction, that we are a more cleanly people than our ancestors —that the boots and shoes of 1843 are more resplendent than those of 1743. A city clerk or a London tradesman, instead of applying to the shoe-black at the corner of a court, and staying there until "the foot grows black that was with dirt embrown'd," now has the mirror-like polish imparted to his boots before he leaves his home: he does not leave his door in search of an agent of cleanliness, for every house has now such an agent within.

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* *London*, vol. i. 'Clean your Honour's Shoes,' p. 18.

We are not about to instruct the reader how to make a bottle of blacking; but we hope to convey a slight idea of the large and remarkable extent of the arrangements involved in the manufacture, as carried on by a celebrated London firm. If any one were to picture to himself a dark and dirty room, containing a few tubs and coppers, and half a dozen men mixing up and bottling a black liquid—their faces and garments vying with the tubs and floor in blackness (and such a picture is not unlikely to be formed), he would be somewhat surprised at witnessing, as we have recently done, the scene presented at "Day and Martin's" factory in Holborn. Whether we regard this establishment in respect to its elegant exterior, the large and lofty packing-warehouse which forms its main apartment, the ranks and files and tiers of bottles in the 'filling-rooms,' or the general economy which pervades the manufacture of a commodity apparently so humble as blacking, there is much to admire, and, perhaps we might say, much more from which instruction might be reaped; for the division of labour, and the apportionment of duty, so that every man may be ready to do the work at the moment when the work is ready for him, and have just as much to do as will occupy his whole working-day, are features of factory-economy in which much ingenuity and calculation are called for.

All the world has heard of "Day and Martin." The two names are so associated that we can hardly conceive a Day without a Martin, or a Martin without a Day; and that either Day or Martin should ever die, or be succeeded by others, seems a kind of commercial impossibility—a thing not to be thought of. "Day and Martin" it has been for forty years, and "Day and Martin" it will probably be for forty years to come, or perhaps till blacking itself shall be no more. To "Day and Martin's," then, the reader's attention is directed.

Those who knew High Holborn a dozen years ago may perhaps remember the former premises occupied by this firm: unimportant and inelegant, they called for no admiration without, and probably possessed little symmetry of arrangement within. Since then, however, the whole of the premises have been built on a scale of great magnificence. On the north side of Holborn, between Red Lion Street and Kingsgate Street, a frontage of about ninety feet shows the façade of the new building. As all the manufacture is carried on in the rear of the premises, the front buildings are leased off to other parties, with the exception of the central portion, which pertains to the factory. From the arched entrance, the premises extend a distance of upwards of two hundred feet northward, to a street running parallel with Holborn; and the working parts of the factory are nearly a hundred feet in width. The site on which the factory stands affords an instructive example of the value imparted by manufacturing premises to the land on which they are situated. This site, and a considerable portion of ground near it, were purchased, many years ago, by the parish authorities of St. Clement Danes, for a sum of one hundred pounds, which was put into the poor-box by some benevolent person. The rack-rent of this same portion of ground now amounts to four thousand pounds per annum, and will probably go on increasing in value!

On entering from Holborn, we come first to a range of offices and counting-houses, lying on the right-hand side of the main archway or entrance. The polished mahogany desks and cases of these offices are the scene of book-keeping operations of the customary kind, and do not call for notice here. At the north end, the wide entrance passage terminates in a large arched window, between twenty and thirty feet in height, a door in the lower part of which leads to the 'warehouse,' the central portion of the whole establishment. This warehouse has a striking effect, both from its wide and lofty dimensions, and from the busy operations of which it is the theatre. Its area is perhaps not much less than a hundred feet square; and its general arrangement will be better understood if we divide it into three portions, a centre and two sides, running parallel from north to south. The central portion is open from the ground to the iron roof, a height of probably fifty feet. It is lighted by about a dozen skylights in the roof, and by an ornamental kind of window, or glazed scroll-work, extending along both sides between the walls and the roof. This central area is separated from the side aisles (if we may so term them) by arches and piers of brickwork, beyond which are these side warehouses, lighted only from the central skylights and windows.

The northern end of the warehouse presents, in the lower part, an arched entrance to another warehouse or store-room beyond, and at the upper part, doors and windows belonging to the 'tun-room,' or manufactory in which the blacking is made. Two light and elegant iron staircases lead from the floor of the warehouse to the level of this upper room, one on each side. The side warehouses or aisles are not above half the height of the central portion; for they have over them two very long rooms or galleries called 'filling-rooms.' Four openings furnish communication between these filling-rooms and the warehouse, two on each side; that is, one opening to each, in communication with the iron staircase, and one by which crates are hauled up to, or lowered from, the filling-room. If the side of each filling-room were thrown open, the whole would bear some resemblance to the form of a church: there would be a nave, or middle aisle, two side aisles, and two galleries over the latter.

This warehouse, from morning till night, is a continued scene of bustle and activity. It is the part of the premises in which the finished commodity is packed for London shopkeepers, for country trade, or for foreign shipment. Packers and porters and coopers occupy the greater part of the central area. The coopers are making or altering and adjusting the casks in which the bottles are generally packed; for many of the casks are made here from the rough staves, and all are fitted to the wants of the packers. The packers are in all sorts of attitudes, according to the state of the cask which is being filled: some are bending over the cask, to put in the lower layer of bottles; some, by having nearly filled a cask, are enabled to stand more erect at their work; one man has got his foot in a cask, pressing down the straw; another, with a stick in his hand, is thrusting straw between the bottles; some are heading or closing the casks; and the porters are arranging the filled casks ready for removal from the factory. At night, both the filling-rooms and the warehouse are lighted with gas, by branches ranged along the centre.

The side warehouses, or those portions which are separated from the centre by the arches and piers, are crammed with enormous piles of stores, pertaining to some branch or other of the manufacture. Casks ranged by scores and by hundreds; staves and hoops for the use of the coopers; crates of empty stone bottles; huge bags of corks or bungs, containing a hundred gross or more in each bag; boxes for packing 'paste-blacking'—these are some of the multitudinous stores here deposited. An underground furnace and boiler, under each of the galleries, furnish hot water for heating the whole premises; and subterraneous communication is kept open from one side of the building to the other. Under the right-hand gallery is deposited a kind of fire-escape, consisting of a series of ladders capable of sliding, telescope-like, to a height of a hundred feet; by which any part of the walls or roof may be reached from below, either for cleaning or repairing, or any more urgent purpose. Near the south-eastern corner of the warehouse are several rooms devoted to the labels, papers, and wrappers, to which we shall allude further by and by; and over some of these rooms is a very large reservoir, from which an abundant supply of water can be obtained in case of emergency.

Before ascending the flights of steps which lead up to the galleries, we will follow out the lower range to its northern termination. An archway leads from the large warehouse to a smaller store-room filled with stores like the other. The western exhibits rows and piles of casks heaped up to the ceiling; while crates are here and there deposited, containing bottles afterwards to be filled, each crate holding about a hundred dozens. At the eastern side of this store-room is a kind of washing-house, where old and used bottles are cleansed before being employed again. Every one who is learned in the matter of domestic perquisites knows that old blacking-bottles, like old things of many other kinds, can find a market: the manufacturer would probably be quite as well pleased to use new bottles altogether, and save himself the trouble of washing old ones; but whenever this washing is necessary, it is effected in the washing-house. Coppers, and tubs, and brushes, sloppiness below and steam above, all indicate the somewhat dirty occupation of bottle-washing; while near at hand are the crates into which the cleansed bottles are put.

In this part of the factory is also a furnace and the necessary apparatus for preparing the red wax with which the corks of blacking-bottles are sealed. Those who know anything of the nature of sealing-wax, whether the finer kinds for sealing letters, or the coarser kinds for sealing bottles, need hardly be told that 'wax' is altogether a misnomer, for there is no wax in it. It is a compound of several resinous substances, coloured by some one among the numerous mineral colours. In the finer qualities, gum-lac is the principal resin, spirit of wine the principal solvent, and vermilion the chief colouring substance. Among manufacturers, however, common resin and spirits of turpentine and Venetian red, or some analogous materials, are sufficiently good for the materials of 'bottle-wax.' In this part of the factory bags and boxes and tubs of the ingredients are disposed conveniently for the manufacture, and a particular kind of furnace is provided for melting them. This furnace is deeply imbedded in brickwork, and situated in a recess quite secluded from any other part: it has also a very heavy iron shutter which can be drawn down in front of it in an instant, and thus render the occurrence of an accident from fire scarcely possible. The melted ingredients, when thoroughly mixed, are poured into vessels to cool, thence to be removed and re-melted in a way of which we shall speak hereafter.

Proceeding still farther northward, we come to a pair of folding-gates, which open into the last portion of this range. We here find the cart and waggon house, where the carts and waggons are kept which convey the manufactured article to the London dealers, to the coach, waggon, canal, and railway offices, and to the docks and shipping wharfs. On each side are stables for the horses, over which are corn and hay lofts. This brings us to the extremity of the range, to which an entrance is obtained by folding-gates from a small street beyond.

Let us now return to the great warehouse, and ascend one of the iron staircases to the upper range of buildings. Having surmounted this stair and reached a platform which crosses the northern end of the warehouse at a height of above twenty feet from the ground, we obtain a bird's-eye view of the operations below; and a busy scene it is. The coopers and packers are distributed about the whole area below; crates of empty bottles are being hauled up, and other crates of filled bottles are being lowered. Opposite, at the southern end, a large clock meets the eye; and through the large arched window we catch a glimpse of bustling Holborn.

Passing from this platform or passage into one of the galleries, or 'filling-rooms,' we find doors leading into the northern range of upper rooms, comprising those in which the manufacture is principally conducted. One of these, used as a store-room, opens upon the street behind, from which tubs, and butts, and casks of ingredients are hauled up and stowed round the room. The vinegar comes in in casks of sixty gallons each, the oil in larger casks, the 'ivory-black' or other kinds of black in casks containing nearly a ton each, and the remaining ingredients in packages and casks of various kinds, according to their quality.

From the store-room the ingredients are brought into the 'tun-room,' or manufactory, the least attractive but the most important place in the establishment. It is singularly occupied. Nearly a hundred tubs, each capable of containing about a hundred gallons, are ranged from end to end of the room in regular rows. Each tub is supported on a separate stand, or trestle, half a yard in height; and each one is capable of being moved by a couple of men at a certain stage in the manufacture. The tubs are all more or less filled with blacking, according to the hour of the day when they are seen. A few of them are filled with blacking of a stiffer or thicker consistence. The room also contains other vessels and apparatus connected with the manufacture.

On either side of this room are smaller rooms, in which subsidiary portions of the manufacture are carried on. In one are the vessels and arrangements for filling pots and tin cases with paste-blacking; and round this room are stored in immense number cylindrical packets, each containing a dozen tin boxes, intended for the use of the army. A soldier is by no means over-provided with room for his implements and appurtenances, and a bottle of liquid-blacking would be rather a burden to him. Yet, as the soldier's boots or shoes must to some extent emulate the brightness and glitter of the boots of those who pay for battles instead of fighting them, a portable blacking apparatus is provided. The blacking, instead of being liquid, is made into stiff paste, and in that state is put into circular tin boxes, about three inches in diameter, and half or three-quarters of an inch deep. What becomes of the tin boxes when emptied—whether they are applied to any useful purpose, or whether, like the millions of pins made every year, they go no one knows whither—we cannot say.

From this room we proceed to the western gallery, or 'filling-room,' a room in which bottles certainly have the ascendant; for what with hauling up and opening crates, and disposing bottles on benches, and filling, and corking, and sealing, and labelling, and storing on shelves, it is certainly the busiest 'bottle-department' we have seen. The arrangement of this room is well adapted to facilitate the rapid progress of the manufacture. It is about ninety feet in length, and perhaps one-third as broad. Along the middle extends a double row of shelves or stands, three or four in height, each shelf being calculated to hold bottles. Along the eastern and western walls are similar tiers of shelves or stands adapted for similar purposes. In the two avenues which separate these series of shelves are broad benches, fitted for holding the bottles during the processes of filling, corking, sealing, pasting, &c. At about the middle of its length is a door or opening in the east side, which places the filling-room in communication with the warehouse below. A crane is fixed immediately outside this opening, by which crates of empty bottles are drawn up from the warehouse, and baskets of filled bottles lowered from the filling-room. The tiers of shelves in the room are fixtures; but the benches are provided with castors or wheels, by which they may be moved from place to place, according as convenience may require. The room is lighted by ten or a dozen skylights in the daytime, and by gas at night, or rather in the evening. According to the time of the day when the filling-room is visited will be the nature of the operations witnessed; but at all hours, from an early time in the morning till eight in the evening, men and boys are actively engaged in the operations which intervene between the making and the packing of the blacking.

The western filling-room communicates with two of the manufacturing rooms, and also with the iron platform stretching across the northern end of the warehouse. We will therefore pass along this platform and visit the eastern filling-room, which resembles the other in its main features. There are ranges of shelves for bottles, disposed one above another, and in parallel lines; but the eastern half of the room is somewhat differently arranged. Here the shelves, instead of being occupied by bottles, contain trays filled with blacking of a different kind, placed there to cool and solidify. The benches, too, and the operations of the workmen, are adapted to the preparation of paste-blacking rather than that of a liquid kind. All the shelves in the two filling-houses are capable of containing six or seven thousand dozens of bottles; and as these bottles seldom remain many days on the shelves before they are packed, an incessant interchange is going on—from the manufactory to the filling-room, from thence to the warehouse, and from thence to the purchaser. The odour of the filling-rooms, as of those more immediately pertaining to the manufacture, gives to a visitor unmistakeable evidence that vinegar is one, and a principal one, of the ingredients employed.

We have now made a tour of the rooms of this remarkable establishment, and may next endeavour to give a slight outline of the modes of proceeding in the course of the manufacture. There is, to be sure, nothing very elaborate, no complicated machinery, no array of engines and machines for making the commodity produced; but still there are some manipulations which strike a stranger as being not a little curious, illustrating as they do the dexterity which is acquired by long practice in some one particular department of labour. This dexterity of hand (which, by the way, is exactly expressed by the French word "legerdemain," although we usually attach a *conjuring* meaning to this term) is most frequently exhibited in branches of manufacture where machinery has not been extensively introduced, and is often more interesting to a looker-on than the complicated action of an elaborate machine.

There are many ingredients employed in the making of blacking, each manufacturer having a recipe of his own. If, therefore, the reader should look out for an exposition of the whole affair, the names and proportions of the ingredients, the temperature of mixture, and so on, we shall not be able to furnish these details; for—to use an expression which Scott puts into the mouth of one of his characters, in relation to a very different subject—"we cannot, if we would; and we ought not, if we could." Let it suffice for our present object to know that ivory-black or some similar substance constitutes the principal colouring material, and that water, vinegar, and oil are the principal liquids.

At five o'clock in the morning, winter and summer, the manufacture of each day's quantum of blacking commences. The work is not extended from day to day, one portion of the manufacturing processes being effected on one day and the remainder on another; but each day's labours are complete in themselves, so that a 'day' at a blacking-factory is a tolerably uniform day. The 'tun-room,' or that part of this establishment which is called the 'manufactory,' is the scene of operations in the first instance. The mixing-vessels are ranged in rank and file over the greater portion of the room. A stirring or mixing apparatus is ingeniously contrived so as to be applicable to all the vessels, one after another, and is worked through the medium of a shaft descending to a room below, where the moving power is applied. The oil, the black, the vinegar, and the other ingredients are brought from the adjacent store-room, and are mixed and worked up in the requisite proportions; the temperature, the stirring, and the general order of processes being of course dependent on the system of manufacture which the firm pursues.

While the manufacture of the commodity is being thus carried on in the northern part of the premises, the other workmen, in the 'filling-rooms' and warehouse, are preparing for the bottling arrangements. The bottles employed, as most persons are probably aware, are made of brown glazed earthenware: they have very wide mouths, and are made of three different sizes, calculated to hold a pint, two-thirds of a pint, and one-third of a pint respectively. They are principally made at the Derbyshire potteries, and are brought to London packed with straw in large crates, each crate containing on an average about a hundred dozen bottles, and weighing half a ton. The crates are first deposited on the floor of the warehouse, and are thence hoisted up to the 'filling-rooms' by means of the large cranes seen in our frontispiece. When a crate is deposited in the filling-room, it is at once opened, and the bottles passed on with great quickness from hand to hand, and laid in regular rows on the broad benches near the centre of the room.

When the bottles are all thus arranged, and the blacking is in a prepared state, the latter is brought out of the tun-room or manufactory by several men, each tub or vessel being brought on the stand or frame by which it is supported. These vessels, to a considerable number, are then placed at equal distances near the bench which contains the empty bottles; and the process of filling then begins. Each vessel is attended by a man and a boy, the latter of whom continually stirs the blacking till the whole of it is bottled. The man stands by the side of the vessel with his left hand next to the bench of empty bottles; and in his right hand he holds a measure, or small can. Taking up a bottle in his left hand, he fills it with blacking by means of his measure; the size of the measure, and the quantity of blacking which he

Filling—Fig. 3.

collects in it at each dipping into the vessel, being so adjusted to the size of the bottles as to expedite the process as much as possible. The laying-down of the filled bottle and the taking up of an empty one are but the work of a moment; every little circumstance being pre-arranged which could in any way facilitate them.

It might at first thought be supposed that this process would be effected more quickly if the liquid were drawn out of a large vessel at once into the bottles by means of a cock or valve. But there are doubtless good reasons for adopting the opposite course. It may be that a sediment would fall to the bottom of the vessel, or that the liquid would flow from the cock too rapidly to enable the filling of each bottle to be adjusted to the required point; for the quantity poured into each bottle is very exact. But be this as it may, the filling is effected by hand; several open vessels being ranged along the filling-room, and each one being attended by a man and a boy, whom we may perhaps term a 'filler' and a 'stirrer.'

The corking of the bottles is the next process. We have said that, in the warehouse beneath, the corks are sorted in bags or sacks containing a hundred gross (fourteen or fifteen thousand) each. These bags are opened, and the corks are sorted into different parcels, according to the sizes of the bottles for which they may be adapted. They are then conveyed to the 'filling-rooms,' and the process of corking commences. A man, provided with an ample supply of corks, proceeds along the range of benches on which the filled bottles are placed, putting a cork into the mouth of each bottle, but without staying to fix or drive it in. Another man, provided with a wooden mallet, immediately follows him, and forces the corks so far into the bottles, that the upper surface of each shall be level with the top of the bottle, a succession of smart blows being given to one cork after another. All this progresses with very great quickness, the bottles being ranged with such regularity as to afford every facility for the operation. Of the thousands of bottles which are filled every day, all are corked in this way, by a sufficient number of men, each pair taking one bench or range of benches.

The bottles are filled, and the corks are adjusted in their places; but sufficient has not yet been done to secure the blacking in its prison-house. When a cork is so large as those here employed, the escape of the liquid contained in the bottle can scarcely be avoided unless some cement covers the whole surface of the cork and mouth of the bottle.

A coarse kind of sealing-wax, as we have before observed, is used for this purpose, and is of course applied in a melted state. In some of the upper rooms of the factory are several portable stoves for melting the wax. These consist of tripods, supporting a brasier or pan for containing ignited charcoal; and immediately above the brasier is a kind of bowl or ladle for containing the sealing-wax. This substance, after being prepared, as was before alluded to, in the lower part of the factory, is taken up in lumps, and melted in these bowls or ladles. When melted, it has a cream-like consistence, and presents the well-known red colour. This apparatus being ready, and placed close beside the ranges of filled bottles, a workman proceeds to seal the corks. He has no brush, no ladle, no contrivance for pouring the wax on the cork; but, holding the bottle upside down, he just immerses the corked surface in the liquid wax. Practice has enabled the men to effect the dipping so exactly, that the wax rarely comes over the sides of the bottle. The apparently simple matter of reversing the bottle again, without scattering the wax, or causing it to flow over the sides of the bottle, is effected by a peculiar movement of the wrist and hand, impossible to describe, and difficult to imitate. Many of our manufactures present analogous instances, in which a process is effected quite as much by the muscular movement of the hand as a whole, as by the delicate agency of the fingers. For instance, 'imitation' or 'mock pearls' are made by blowing

Sealing.—Fig. 4.

glass beads, so that each bead shall be hollow and shall have two holes in the exterior; then a liquid, made of a pearl-like powder obtained from the scales of fish, is dexterously blown into the hollow of the bead through a tube; and by a peculiar twisting of the hand, this single drop of liquid is made to diffuse itself over the internal surface of the bead, without having more or less than just enough to cover the whole. Again, in type-founding, when the melted type-metal has been forced into the mould, the caster throws up his left hand with a peculiar motion, giving it a kind of jerk at the same time with his right, by which the liquid metal is forced or shaken into all the minute interstices of the mould. Instances of this kind might be adduced in great number; and among them is this one of sealing the filled bottles. The celerity, too, with which this is effected is not less note-worthy than the neatness; for a man can seal one hundred dozens of bottles in an hour, or twenty in a minute.

The sealing, as well as the filling and corking, is effected in the two 'filling-rooms;' and so is likewise the next process, which is perhaps to a stranger the most remarkable of all which the factory presents, from the astonishing rapidity with which it is effected,—we allude to the pasting of the labels on the bottles. But before speaking of this process, it will be desirable to pay a little attention to the labels themselves, the complexity of which has doubtless puzzled many persons.

Those who have not watched the proceedings of the last few years in respect of *colour-printing*, can perhaps scarcely conceive how the printing of these blacking labels can be effected. If we examine one of "Day and Martin's" labels, we see that nearly the whole of the ground consists of a kind of lace-work, printed in red on white paper, the meshes or interstices being probably about one-twentieth of an inch in diameter. This ground-work, occupying about sixteen square inches, is diversified by several compartments printed in black ink: one, for instance, containing a view of the front façade of the factory; another, the name of the firm; a third, the retail price of the commodity contained in the bottle; a fourth, the number of the house, curiously bedecked with a double enunciation of the name of the firm; and two others containing remarks and directions to the purchaser. All these are printed with black ink on the white paper, no red lace-work being here seen. Above these are letters printed in black and white on a wavy or undulating ground of black, red, and white; while at the top are black letters, and at the bottom letters in white, red, and black, printed on, or at least interspersed among, the lace-work ground itself. All this relates to the labels for the liquid blacking contained in bottles; and the circular labels for paste blacking are on the same principle, though different in detail.

Now it may naturally be asked by those to whom the subject is new, how these various devices, and these differently coloured inks, can be imprinted on one piece of paper without confusion or distortion. Without going into any description of the various modes by which printing in diverse colours is now effected, we will attempt a brief sketch of the contrivance by which these labels are produced. One of the rooms in the factory is a printing-room, in which is contained a beautiful machine, invented by Mr. E. Cowper, of King's College, who was the original patentee of the machine by which this volume is printed. It is a cylinder printing-machine, specially adapted for printing many-coloured devices, such as those on the labels. There is one cylinder for printing all the red portion, and another for printing the black. Eight labels are printed at once, but it will simplify the description if we speak only of one. In the first place a stereotype plate is arranged for receiving the device of the black portion of the label; and another, exactly the same size, for the red portion. These plates, for the liquid blacking, measure rather less than five inches by four; and on the surface is depicted, *in relief*, all the letters and ornaments, which are afterwards inked and printed; the plates being prepared, we believe, by a combined process of casting, stamping, and modelling. The plates are so exactly adjusted, that every *raised* part in one of them shall coincide with a *depressed* part in the other, and *vice versâ*. This is in fact precisely the same principle as that on which the several blocks for printing floor-cloths are adjusted, as described in a subsequent page of this volume. The nature of the adjustment might be instructively shown by printing a label *by hand* with the two plates; although, of course, this would never do in practice. We might take one of the plates, carefully ink its surface either by an inking-ball or an inking-roller, and then impress it on a piece of damp paper. Then (supposing the first inking to have been black), if we ink the second plate with red, and print the paper a second time, the clearness or confusion of the resulting device would correctly measure the degree of accuracy with which the one impression was superposed on the other. It would be seen how very small a deviation from exactness in the adjustment of the second plate would be sufficient to give a distorted appearance to the label.

If the printing-machine were adapted for flat printing, these prepared plates might be adjusted to a flat bed or support. But a cylinder-machine is employed, in which both the plates lie on the surface of cylinders. Here, however, a difficulty at once occurs. If flat plates be placed on a curved surface, it is easy to see that they cannot conform to the curvature of that surface; and the mode of contact between the plates and a sheet of paper to be printed would be wholly incompatible with the object in view. The means had therefore to be devised of *curving* the plates without disturbing the device on their surfaces; and this has been effected. Eight plates, all exactly alike, are bent in conformity with the curvature of the cylinders, and are then fixed to the surface of one of the cylinders by means of delicate adjusting mechanism. Eight other plates, all alike, but differing from the former, are similarly fitted to the surface of the other cylinder. These two cylinders are so adjusted in the machine as to rotate in contact, or nearly in contact, with a third, round which a sheet of paper may be made to travel. An inking apparatus for black ink is placed near one cylinder at one end of the machine; another apparatus for red ink is fixed near the other cylinder at the other end; and when the machine is at work, if a sheet of damp paper be placed at one end, it is drawn into the machine, carried over and under various rollers, and made to pass under the two cylinders. Meanwhile, by various rollers and other connecting mechanism, the eight plates on the one cylinder become coated or charged on the projecting parts with black ink, and those on the other with red; and matters are so adjusted, that exactly when the paper comes near the black-inked cylinder, the plates are ready to print; and immediately after the paper has received its black impress, it is caught by the other cylinder and printed with the red portion of the device. As may be readily supposed, the most scrupulous exactness of adjustment is necessary, in order to ensure the juxtaposition of the red and black portion of the device at the proper places. By means of adjusting-screws, the printing-plates can be shifted to so minute a distance as the two-hundredth of an inch, in order to bring the 'register,' or superposition of device, at the proper points. One grain of ink only is used to print eight labels. The circular labels for the paste-blacking tin boxes, as well as the square ones for the bottles, are printed at this press. The demand is so large and so constant, that the machine is nearly always at work; and when the sheets of labels are printed, boys are employed to cut the separate labels from them.

These are the labels, then, which we are now to see pasted on the bottles. One man or boy can paste as many labels as two others can attach to the bottles, so that they work together in groups of three. On the bench is placed on the one side a large tub of paste, and on the other a ranged series of filled and sealed bottles. A heap of labels is laid down face downwards, and the paster pastes them one by one with a brush. The dexterity in this simple act is not in the pasting, but in a peculiar final touch with the brush, by which the pasted label is jerked off the heap, and caught in the left hand. So rapidly is this effected, that a man or boy will paste a label, jerk it off the heap, catch it in his left hand, and lay it on one side, nearly two thousand times in an hour; for one workman can thus paste a hundred and sixty dozen labels in this time. As fast as the labels are pasted, the other two workmen attach them to the bottles. Each one takes a bottle in his left hand, and a pasted label in his right, and attaches the one to the other by two or three touches which the eye can scarcely follow. To a spectator it seems that almost before the bottle is taken fairly into the hand, it is laid down again properly labelled. Let any uninitiated person endeavour thus to secure sixteen labels per minute to as many bottles, and see what progress he will make.

Labelling.—Fig. 5.

The labelling of the bottles is the last process which is effected in the filling-room. All the bottles, after having been labelled, are ranged on the systems of shelves in the filling-rooms, and there kept till the paste is properly hardened. They are then put into a basket, and lowered from the filling-room to the warehouse by the aid of one of the cranes. Here they pass into the hands of the packers and coopers. The general mode of sending out the bottles from the factory is in casks, containing from three to a hundred dozens. The casks are prepared by the coopers to the proper dimensions, and the packers proceed with their work. This, like many other apparently simple operations, requires tact and judgment. The packer first ranges a circle of bottles round the inner surface of the cask, then encircles a wisp of straw within this ring of bottles, and then arranges a smaller ring. In this way he proceeds till one tier is filled; and by the aid of a stick or wedge he inserts straw and extra bottles wherever there is room for the one or the other, until at length the whole are jammed immoveably together. A second tier of bottles is then built up, separated from the lower one by a layer of straw; and this is in a similar manner hardened and compressed till nothing can shake about or become displaced. So on to the top of the cask, which is finally topped with straw, and the head fastened in, ready for marking and carting.

Such is the career of a bottle of blacking before it leaves the hands of the manufacturer. But there are one or two other forms of blacking which we may briefly notice, in illustration of the arrangements of this factory.

We have before said that in one of the rooms of the factory small tin boxes are piled in great number, and that these contain, or are destined to contain, paste-blacking for the use of the army.* Whether any particular ingredients are used in this composition, different from or in addition to those which compose liquid blacking, we do not know; but the consistence to which it is mixed is much stiffer. The paste-blacking, when fully prepared, is contained in a large vessel or tub, round which two or more boys place themselves, each one provided with a small scoop or ladle, shaped like a spoon, with the handle affixed to one side instead of one end. Tin boxes are close at hand, which the boys take one by one, and fill with the thick paste-like blacking. All the boxes, as they are filled, are ranged in rows in the filling-room, where they remain till the blacking has solidified, and assumed a stiff clayey consistence. Then tin covers are put on them, and they are packed in dozens, and wrapped in paper. They reach the soldiers, we believe, through the medium of the army clothiers.

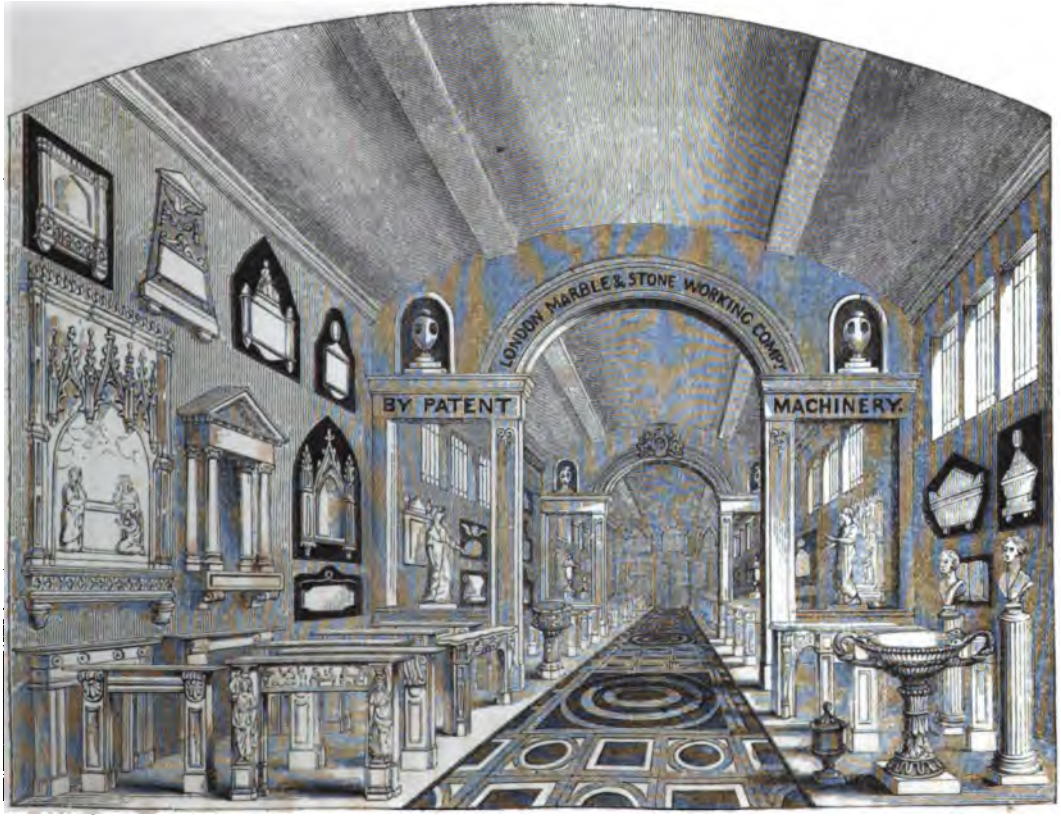
There is another kind of paste-blacking which is sold in little wide-mouthed stone pots, something like crucibles. This is nearly the same in quality as the soldiers' blacking; while the pots are of the same character, as to material, as the bottles. The paste-blacking is laded into them by the same simple apparatus as into the tin boxes, and is then allowed to stand aside to solidify; after which the mouths of the pots are well secured with paper.

Another form of blacking, different from all the others, remains yet to be noticed. This is a kind which is stiffer than liquid or bottle blacking, but thinner than the other kinds: it is in fact a soft paste. Its mode of being packed into a saleable form, after the manufacture is finished, is very different from the other instances. Shallow moulds or trays are provided, about half a yard long, two-thirds as wide, and half an inch or so in depth. Into these moulds the paste-blacking is poured or laded from a large vessel; and the moulds are then put by on shelves to cool and solidify. One side of the eastern filling-room contains a very large number of these moulds, standing by till their contained blacking has become cool. When this cooling is effected, each tray or mould is laid flat on a bench, and one of the edges or ledges is removed, so as to enable a knife to be passed under the solidified blacking, as a means of loosening it from the bed of the mould. The whole sheet of blacking, if we may so term it, is then cut

Packing Paste-blacking.—Fig. 6.

up into six dozen rectangular pieces, twelve in the length of the sheet and six in the width, by a convenient kind of knife; and the cakes are then in the shape in which they are sold. But they are too soft to be left without a covering; while, on the other hand, they require neither bottles, pots, nor tin boxes. Pieces of paper, first printed with the name of the manufacturer, &c., are well saturated with oil, and when dry, are fit to be used as wrappers to the small cakes of blacking. The papers are laid flat on a bench, one cake is put into each, and by one of those neat and expeditious manipulations which so many other parts of the factory exhibit, the cakes are wrapped up, each in its oiled paper. Then, in order to sell these cakes to the dealers in a form fit to be handled, small wooden boxes are provided, each capable of holding a certain number packed neatly one upon another.

Thus have we rapidly sketched the chief manufacturing features of the place, so far as is necessary for the present object. Every day, we have said, witnesses a pretty regular and uniform series of operations. The actual manufacture takes place at an early hour in the morning; while the bottling, corking, sealing, labelling, moulding and wrapping cake-blacking, bottle-washing, &c., occupy the remaining hours of the day in the upper and hinder rooms. The packing in the warehouse is so arranged as to enable the waggons and carts to be dispatched with one cargo to the various dealers, wharfs, docks, &c., in different parts of town, at a pretty early hour in the morning, and with another cargo at a later period of the day. Taken altogether, it must be owned that a day at "Day and Martin's" is an early day, and a long day, and a busy day.


LONDON MARBLE & STONE WORKING COMPY
BY PATENT
MACHINERY.

XI.—Show-Room of the London Marble Working Company, Esher Street, Millbank, Westminster.—Face p. 233.

XI.—A DAY AT THE LONDON MARBLE-WORKS.

The cutting of a piece of stone, and bringing it to a form and appearance adapted to the purposes of the builder, are operations which, until the last few years, have undergone but a very slight amount of change. The pickaxe at the quarry, and the saw and chisel at the mason's yard, have probably for ages been the instruments by which these operations have been conducted; and, indeed, so far as regards the common building-stones, the same remark may be made in our own day. The more costly kind of stone, to which we give the name of *marble*, and which, from its nature, is susceptible of a high and durable polish, requires for its due preparation an amount of labour far exceeding that which is customarily bestowed upon the commoner kinds of stone; and this circumstance has led, within a period comparatively recent, to the construction of machines which enable the processes of sawing, grinding, polishing, &c. to be performed with more expedition and less expenditure of manual labour than characterized the same operations formerly. Were it not for this circumstance, we should not probably have called the reader's attention to this department of mechanical art; but there are many points connected with the subject at the present day which deserve a little notice.

So far as stone is employed in large blocks for the construction of buildings, strength and durability are the chief qualities for which the material is valued; but when we have a substance such as marble, in which delicacy and purity of colour are combined with a susceptibility of receiving a high polish, and of being cut into elegant forms, a new measure of value is obtained: our notions of *taste* and *beauty* are at once appealed to, and the refining influence which objects of taste exert on mankind is shared by this substance in common with some others. That this is felt to be the case, is shown by the evidence given before the parliamentary committee on the Arts and Principles of Design, in 1836. It appeared to be an opinion on the part of many members of the Committee, that if so beautiful a substance as marble could be brought more plentifully and economically within the reach of the inhabitants of this country, it would tend to advance the arts of design, and to diffuse a taste for the elegances which are so well appreciated in Italy. On this subject, Mr. Cowper gave the following evidence in answer to questions put to him by the Committee:—

"613. Would you not conceive, if the arts were generally diffused among the people, the black marble of Derbyshire and different marbles would be converted to purposes at present almost unknown? —Certainly.

"614. Is there not some tendency now existing towards the conversion of that and various marbles to purposes of art?—There is, both as to the various marbles and various other materials. At the marble-works, Esher Street, Horseferry Road, there is a beautiful system of machinery for working ornamental marble; mouldings, slabs, and pilasters of beautiful workmanship, are executed in British and foreign marble at a low price. The whole is the contrivance of Mr. Tulloch, an independent gentleman of great taste, as his large collection of paintings by the old masters testifies. He, from observing the great use of marble in Italy and in other countries, contrived this machinery for the express purpose of introducing marble into more general use in this country."

After a few questions relating to a patent mode of carving busts in ivory, Mr. Cowper was asked—

"632. If applied to oak or hard wood, the expense would be considerably lessened?—Yes; and I have seen the most elegant parquetry floor made by it, which would be too expensive to be attempted by hand. Much, if not all, of the Gothic oak carving for the new houses of parliament might be done by it; and with Mr. Tulloch's machinery in Esher Street, almost all the Gothic stone mouldings might be executed; so that by this application of art to manufacture, the splendid palace of the legislature might itself be increased in splendour.

"633. Could it be used for working in wood and wainscoting, and for ornaments?—Yes; and there would be no difficulty in doing so."

As it may not be uninteresting to the reader to know the means by which marble may be thus brought into a useful and ornamental form by machinery, we shall in the present paper detail the results of a visit recently made to the establishment referred to in the above evidence, illustrating our remarks by a few wood-cuts, and by such descriptions as will explain in a familiar way the action of the patent machinery, without attempting minute detail.

It is necessary to state the distinction between marble and other kinds of stone. This term is applied to those finer varieties of granular and compact limestone, which, being of a closer grain, are susceptible of a superior polish, and are remarkable either for their whiteness, their blackness, or the beauty and variety of their colours. In former times the appellation of marble (derived from the Greek verb, to *shine* or *glitter*) was indiscriminately given to many stony masses that admit of being polished; and, accordingly, we find alabaster, serpentine, basalt, porphyry, &c. occasionally included under that term. At present, however, it is customary to confine the term 'marble' to the kinds of limestone above alluded to, whether in a pure state, or varied with foreign substances mixed with or imbedded in the mass, such as serpentine, hornblende, quartz, &c. Where a piece of marble is not purely white (and white specimens are very rare), it has received its tints generally from the oxides of iron, the solution of which has wholly or partially penetrated the mass previous to its complete induration. Blue and green marbles frequently owe their tints to minute particles of hornblende. The black varieties, such as those of Ireland and of Derbyshire, are coloured by carbon, and sometimes by a kind of bitumen.

The ancient statues, of which so many beautiful specimens are still remaining, were formed of marble obtained from quarries which are met with even in the present day; and the general character of all such quarries may be judged from a notice of those at Carrara. Several ridges of low hills near the town of Carrara have been known for the marble-quarries worked there ever since the time of the Romans. The quarries are more than a hundred in number, some furnishing the purest white marble which the sculptor can obtain, and others marble variously tinted and adapted for ornamental purposes. The quarries were worked throughout the flourishing period of the Roman empire, after which they fell into disuse, and did not resume their importance till the Pisans took possession of them in the twelfth century. Of this assemblage of quarries Mr. Simonds observes:—"Formerly on the sea-side, it now forms a deep nook in the mountain behind; but all Italy, all Europe, and all the world, might be covered with temples and peopled with statues of Carrara marble, yet the main stock would sustain scarcely a visible diminution by the loss of such fragments of its vastness. The rock is strewed over with these fragments detached from the heights by pygmies whom you scarcely see above, working with their puny tools, and blasting with gunpowder. The face of the noble rock, exposed for ages to the weather, is black; while the new fractures are dazzling white, and their crystal grain, dimly transparent, looks as if a single stroke of the chisel—a skilful one indeed—might make it breathe at once."* Twelve hundred workmen are constantly employed at the quarries; and the annual revenue is calculated at seven or eight hundred thousand francs. The blocks are carried down from the quarry in carts, drawn by oxen, to the Spiaggia, or beach of Avenza, where the storehouses are situated, and whence the marble is shipped on board the vessels that anchor in the roads. As the freight of the blocks would be uselessly increased if they were exported in misshapen masses, they are frequently sawn into squares by saw-mills, turned by some small streams which flow down the side of the hills in which the quarries are situated.

The marble, thus brought to London in the rough state, whether from Italy, from France, from Ireland, or from the northern parts of England, we will suppose to be consigned to the marble-working establishment before spoken of; and we will proceed to describe the general arrangement of the buildings, and the action of the different machines employed for working it.

Most Londoners, and perhaps most visitors to London, are aware that the Milbank Penitentiary is situated at a little distance north-west of Vauxhall Bridge. Immediately to the north of this building is Holywell Street, out of which branches a smaller street called Esher Street; and in this last-mentioned street is situated the London marble-works; or, to give the full name, the "London Marble and Stone Works;" for other kinds of stone are worked besides marble. The buildings comprise a long front range; three or four ranges of work-shops and sheds; and open yards connecting these ranges one with another.

An arched entrance leads through the front range of buildings into an open court behind. On either side of this entrance are doors, the one on the left hand leading to offices and counting-houses, to which we shall not further allude. The entrance on the right is to a room occupied by monumental tablets and other articles in marble, in a state nearly approaching to completion; as well as plaster casts or models of which marble copies have been made.

From this lower room a staircase leads up to the show-room, which presents a very beautiful appearance. It is a kind of gallery, well adapted for the reception and exhibition of finished works in marble.

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* 'Tour in Italy and Sicily,' p. 576.

The room is of great length, and is lighted by ranges of windows situated near the ceiling on both sides of the room, leaving ample space for monumental tablets, &c. beneath them. A clear passage is left through the middle of the room from end to end; on either side of which are ranged very numerous specimens of finished works in marble, such as chimney-pieces, pillars, pilasters, vases, urns, tables and table-tops, statues, busts, monumental tablets, mouldings, &c. Some of these are very elaborately worked; and, from the diversified colours of the specimens of marble employed, and the taste with which they are arranged, the whole presents a very elegant appearance. Others are nearly plain, and exhibit the accuracy with which the machinery employed can produce flat surfaces of marble, for such purposes as paving for halls, conservatories, dairies, shop-fronts, &c. Most of these objects being temporarily placed in this room, the collection varies from time to time. A short time ago, among the more elaborate works finished at the establishment, were a large Gothic monument, a marble fountain for Sutherland House, and a marble copy of the large vase presented to the British Museum by Lord Western in 1839. At a more recent visit we observed several balustrades and other articles of polished black Irish marble for Hamilton Palace in Scotland.

Descending from the show-room, we pass out into the court or yard behind the front range of buildings. This yard is occupied by large blocks of marble: some in the rough state in which they were brought to London, either merely trimmed with the chisel or rudely sawn into thick slabs; others in a more or less prepared state. Among these we noticed blocks of black marble from Ireland, of the unusually large dimensions of thirteen feet by ten or eleven; and other blocks of white marble from Italy, much smaller in size, and exhibiting examples of the rude manner in which the hand-sawing of the Italians is effected.

To the left of this yard, and extending behind the southern end of the front range of buildings, is another yard, almost entirely filled with marble which has been already cut up into slabs of an inch or so in thickness, and which are deposited here till wanted for the subsequent processes. A few slabs of the finer kinds of stone are among them; but marbles of various colours and qualities constitute the chief materials operated on.

Crossing to the right of the central court or yard, we come to the buildings in which the working processes are carried on. The main building is of two stories, each measuring probably eighty feet by fifty. The lower story or room has doors on the north, south, and west sides, each leading to an open court or yard; while on the east side is a door opening into an engine-room, where a steam-engine, supplied with the necessary appendages of furnace, boiler, fly-wheel, &c. produces the moving-power by which all the machinery is impelled. This large room is so filled with machines in active operation, and the unceasing noise of the sawing and grinding processes is so bewildering, that a stranger requires some little time to analyze the complicated arrangements of the room. By beginning at the source of power, however, viz., the steam-engine, and tracing the communication from one point to another, the skilful arrangement of the whole gradually becomes manifest. The fly-wheel of the steam-engine moves a shaft and a system of cranks, by which four rods are made to move horizontally. Each of these rods, by a reciprocating longitudinal movement, moves a set of saws inserted in frames; and the arrangement of each frame, as we shall presently explain, is such as to admit of a block of marble being cut by these saws. There are thus four sawing-frames or machines, ranged in a rectangular form, two to the north and two to the south of the rotating shaft; and the whole occupying the greater part of the eastern half of the room.

On the western side of the room, next to the door by which we enter, is a 'ripping-bed,' a machine for cutting slabs of marble into narrow strips or into small pieces. Next to this is a 'grinding-bed,' on which the slabs are ground after sawing, and previous to the process of polishing. Beyond, and towards the northern end of the room, is a 'moulding-bed,' a machine by which pieces of marble are worked into the architectural form of mouldings, such as squares, fillets, beadings, hollows, and ovalos. All these machines consist of various parts, to which motion of some kind or other is given, in one of the many ways which are familiar to those accustomed to machinery, but which can scarcely be made intelligible to general readers by written description. Shafts, drums, bands, cog-wheels, racks and pinions, bevel-wheels—all are brought into requisition, according to the kind of motion and the circumstances under which it is to be produced. At the eastern side of the room, in addition to the sawing-machines, is a lathe of large dimensions, turned by a shaft connected with the other machinery. At this lathe circular pieces of stone are moulded, or provided with the architectural mouldings just alluded to; and by it also circular columns are turned.

We will now pass to the upper story of the building, corresponding in size with the lower. This room is lighted on all four sides by windows, and contains a great number of workmen employed principally in the finishing processes of marble-working. There are several openings in the floor, to make room for the upper parts of the large sawing-machines below, and for some of the motive apparatus by which the machines are worked. Between and around these openings work-benches are erected, at which the men are employed. The operations are mostly effected by hand; but there are two machines on the western side, called 'polishing-beds,' at which the finishing operation is given to slabs and other flat pieces of marble. A door from the southern end of this room leads to the show-room.

We now leave the large building, and pass through an open shed or shop attached to its western wall. This shed exhibits an instance of the ubiquity (if we may be allowed the term) of steam-power; for by carrying a shaft through the wall which separates the shed from the sawing-room, three or four machines in the former are set in motion as effectually as if they were in the large building. The first of these, connected immediately with the shaft, is a grinding-machine, for grinding smaller pieces of marble than those operated on by the machine in the large building. Next to this, and connected with it by a revolving drum and band, is a machine for cutting circular slabs of marble of any dimensions up to six or eight feet in diameter. Adjacent to this is a third machine, by which small circles, a few inches in diameter, are cut out of slabs of marble, and by which, with a little modification of arrangement, cylinders, tubes, and columns might be cut. The remaining part of this shed is occupied by workbenches at which men are engaged in sawing, grinding, and polishing small pieces of marble, the working of which scarcely requires the aid of the machines.

A narrow avenue separates the shed just alluded to from a long range of shops, in which those departments of marble-working are carried on wherein the mallet and chisel are the principal instruments employed. Small benches, ranged laterally across the shop throughout its whole length, are occupied by men engaged principally in sculpturing or carving the ornamental parts of marble-work.

Beyond this range of carving shops is a millwright's shop, in which the numerous saws, chisels, and other instruments of iron and steel employed in the processes of the manufacture are repaired and sharpened; and in which repairs and adjustments of the machinery are made. At the left of this is a large open yard entirely filled with slabs of statuary marble, which have been cut by the machines, and are deposited here till wanted. To the right or eastward of the millwright's shop is another open yard, occupied partly by stores of stone and marble not yet brought under the action of the saw, and partly by the sand and the apparatus for cleansing and repairing it, required in the process of sawing.

We have now taken a glance at the general arrangement of the establishment, to show the mutual dependence of its several parts. Our next object is, to trace the progress of a block of marble through the several processes which it undergoes, till its final conversion into slabs, pillars, mouldings, plinths, vases, or other specimens of marble-work. We shall thus have an opportunity of describing the general action of all the machines separately, as they are brought into requisition.

The first machine employed on a block of marble after it is deposited in the manufactory is the large sawing-machine, one of which is represented in Fig. 2. There are five or six of these in operation, but the action of any one will illustrate that of all the rest. The process of sawing must of course be regulated according to the purpose for which the marble is employed. In a monumental

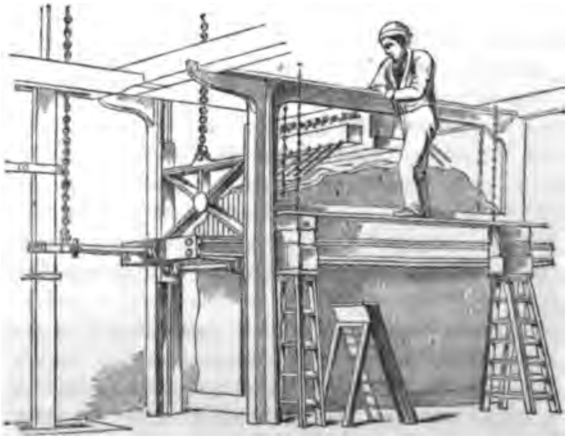

Fig. 2.

tablet, the pieces of marble employed are generally broad, flat, and thin, whether or not they be highly decorated. In a chimney-piece, the several parts are likewise made from rather thin slabs and strips; in marble steps, table-tops, pavements, &c., the same remark applies; and indeed in the larger proportion of articles made of marble, the pieces from which they are formed are flat slabs or sheets, rather than massive pieces. In many of the ornamental purposes to which marble is applied, a foundation of commoner stone, of brick, of wood, or of cement, is first formed, and then the marble is superposed merely as a sort of casing. It results from this mode of using it, that a block of marble is in most cases converted into slabs of an inch or so in thickness before being applied to its ulterior purpose.

This first process of sawing is that in which the application of machinery is perhaps of the greatest importance, not only as regards the expenditure of manual labour, but also in reference to the accuracy with which the cutting is effected. With regard to the first point, many persons must have observed the singularly inefficient way in which the muscular power of a man is exerted in the common mode of sawing a stone. He sits at one end of the stone, grasping with his hands one end of a frame, which contains an iron saw or cutter, and this saw he pushes to and fro as a means of dividing the block of stone or marble into slabs. Now it is manifest, on a very little consideration, that his muscular strength is not equally effective as a working-power during these reciprocal movements; to push and to pull, to draw upwards and to draw downwards, to extend the hands from the body and to draw them to it, are respectively efforts which produce very unequal effects. If we watch the proceedings of a stone-sawyer, we shall also see that the saw frequently 'jars,' or has a tremulous motion consequent on the unequable manner in which it is moved; the result of which is, that the cut is not equally effective throughout the whole length of the block. All these circumstances combine to render the cutting by hand a very slow one.

With respect to the accuracy of the cutting, it may well be supposed that this is with difficulty attained by hand. The blade of the saw or cutting instrument is not above three or four inches wide, and is extremely apt to twist a little out of the vertical plane. If we were to attempt to cut through a large cheese with a common knife, the cut would be more and more irregular in proportion as the blade of the knife was narrower. So in the case of the stone; the narrowness of the blade—necessary to ensure its easy passage through the stone—renders it so liable to deviate from the vertical plane, that a perfectly level cut is almost unattainable by hand. This irregularity produces two ill consequences: it renders a laborious process of grinding necessary, in order to produce a level surface; and it occasions a waste of material, which is of serious importance if the quality of the marble be valuable. Of this latter fact we saw a striking instance. In the central yard of the Marble-works were the two halves of a large and very fine block of statuary marble, which had been cut in two in Italy before exportation. The cutting had been effected by hand; and on glancing the eye along the surface of one of the pieces thus cut, it was obvious that the surface was about nine inches out of a true plane, the saw having twisted in various directions during the process of cutting. The distortion thus occasioned affected both halves equally, for a convex protuberance in one half had a corresponding depression in the other; and to bring both these to a true surface, the middle portion of the one and the edges of the other had to be sawn or ground away to the depth of nine inches. It happened that this block was one of the finest specimens of purely white marble, a fact which could not be fully ascertained until the cut was made; the quality was so valuable, that the portion wasted by the irregular sawing would, if cut into slabs, have been worth a sum estimated by the proprietors at nearly a hundred and fifty pounds.

These are some of the circumstances which render the employment of machinery very important; and Sir George Wright and Sir James Jelf some years ago devised machines for these purposes. Their attempts, from various causes, were not permanently successful; but the mechanism of Mr. Tulloch has now been in operation several years. The sawing-frames each consist of a cast-iron framework, to hold the working machinery together, about twelve feet long. A horizontal rectangular frame, longer than the block to be cut, and wider than the block is thick, has mechanism at each end by which a number of saws may be fixed parallel to the length of the frame, and with the blade of each saw in a vertical plane. By means of pins and wedges, the saws can be fixed at any required distance apart: suppose, for instance, that a block is to be cut into a number of slabs, each one inch thick; an equal number of saws would be fixed in the frame strictly parallel one to another, and exactly an inch apart; so that the saws themselves would ensure the accurate regulation of the thickness of the slabs. The saw-frame is capable of sliding in vertical grooves in the cast-iron supporters, and is balanced by weights connected with it by a chain passing over a pulley above; the saws are thus kept at a height from the ground corresponding to the part of the block which is being cut; and as they are a little heavier than the balance-weight, they gradually descend by their own pressure as the cutting proceeds.

The saws here spoken of are rather unfortunately named. A stone-saw is not a saw at all. It is merely a piece of soft sheet-iron, with a blunt, smooth, straight edge, unprovided with teeth. Its action is not, properly speaking, to *cut* the stone, but to separate the particles of the material by friction. The effect is much increased by the addition of sand and water, the latter of which in some degree softens the stone, while the sharp particles of the former aid the frictive action of the saw; the small hard particles which constitute sand may indeed be deemed substitutes for the teeth of a saw. The quality of the sand is varied according to the nature and hardness of the stone to be cut; coarse sharp sand being used for soft kinds of stone, while very fine sand is better fitted for the harder stones. At the Marble-works the sand employed is obtained from the neighbourhood of Croydon. It is well washed in large vessels, in order to free it as much as possible from extraneous substances; after which it is placed in a large brick receptacle covered with a roof, but open to the air, where it is kept till wanted. The cleanness of the sand employed is a matter of considerable importance; for if a small fragment of wood, or a grain so large that it will not penetrate (but rolls over) the stone, gets among the sand, the action of the saw is much impeded, and the removal of the obstacle very difficult.

We will suppose that a block of Italian marble, eight or ten feet long, five or six wide, and one and a half thick, is to be cut into as many inch slabs as it will make, say sixteen. Sixteen saws are fitted into the frame parallel and equidistant, and the whole are lifted up by means of a windlass acting on the balance weight above, to a height sufficient to allow the block of marble to be placed edge uppermost beneath them. The block is placed as nearly vertical as practicable, and is wedged and supported so as to remain firm. A very ingenious little machine, in which Mr. Tulloch has shown much inventive contrivance, is then suspended over the block, for supplying the saws with the requisite amount of sand and water. In the ordinary method of sawing by hand, a board is placed so as to slope towards the fissure made by the saw; and at the upper part of this board is placed a vessel of water, from which a small but constant stream is running down the board into the opening. A quantity of sand previously washed is also placed on the board at a little distance from the point where the water is running; and a portion of this sand is drawn forward by the workman into the running water by means of a stick with a hook at the end, and carried down gradually into the fissure made by the saw. But by Mr. Tulloch's contrivance several saw fissures are supplied with sand and water at once. An iron cistern, about two feet long, one high, and one wide, is filled with water; and in each side are fixed about twenty cocks. The water, slowly flowing from these cocks, falls into an equal number of little grooves formed in the bottom of a box filled with sand; and these grooves are so constructed that the sand and water flow out together at a number of little openings on one side of the box. These streams of sand and water are then so directed as to flow each into one of the saw fissures. As there are two grooved boxes, one on each side of the cistern, there are two streams of sand and water flowing into each fissure. This is one of those small pieces of mechanism frequently met with in our manufactures, in which more inventive ingenuity is often called for than in machines apparently much more important.

The saws being made to rest on the block, and the sand and water being arranged to flow into the fissures as soon as they are made, the saw-frame is set into reciprocating horizontal motion by a connection being formed between it and the working shaft of the steam-engine. By a particular application of a parallel motion somewhat similar to that of Watt, the saws are moved in a strictly horizontal manner, the length of the stroke of each saw being about eighteen inches. When the saw comes to the end of its stroke, it is lifted up a little by means of an inclined plane, so as to allow the sand and water to flow down beneath it in the crevice. As the cutting proceeds, the assemblage of saws descend by their own weight being a little greater than that of the balance; and the reciprocating motion continues till the block has been entirely divided into slabs.

There are four machines of the kind just described, all connected by rods with the working-shaft of the steam-engine, and all capable of receiving and working an equal number of saws. But within the last few years blocks of black marble from Galway have been procured of such large dimensions that the sawing-machines are not able to receive them: for working on such blocks another sawing-frame has been erected out in the open yard, but still in connection with the working power of the steam-engine. We saw a block of Galway marble, thirteen feet long by ten feet wide, under process of sawing in this frame: it was being cut into slabs for forming the landings of a grand staircase in Hamilton Palace.

After a block of marble has been cut into slabs, it is for many purposes required to be reduced to the form of narrow strips, such as the several parts of a chimney-piece, or of a monumental tablet; or else into small pieces of various shapes. The large sawing-frames are not adapted for this smaller kind of workmanship, which is therefore effected in a machine called a 'ripping-bed,' represented in Fig. 3. This is a kind of table, twelve or fourteen feet long, six or seven wide, and three high, the flat or bed of which is made of cast-iron. On this iron bed is placed one of plank, forming the top of the table; and on this the slabs which are to be cut into strips are temporarily fixed with plaster of Paris. A horizontal axle revolves a few inches above the table, and on this axle are fixed vertical cutters, consisting of circular pieces of soft iron about eight inches in diameter, the lower edge of which, while revolving, nearly touches the table. The iron

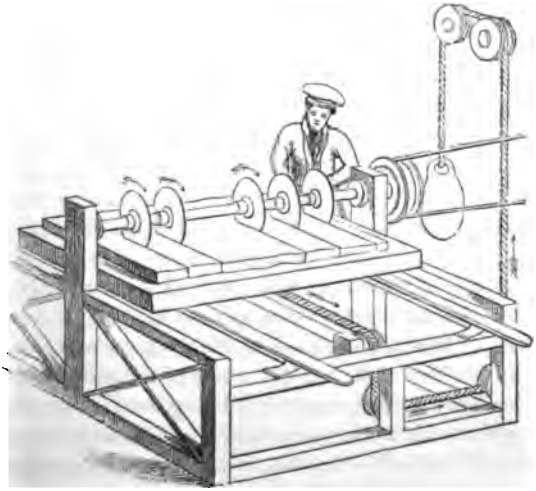

Fig. 3.

bed on which the planking and the slab rest is connected, by means of pulleys, with a heavy weight, by which it is drawn slowly forward; and the edge of the marble, thus forcibly drawn in contact with the edge of the cutter, is subjected to its cutting action, and is pulled forward by the weight as fast as the cutting is effected. The axle, being several feet long, is adapted for the reception of several cutters at once, which may be so adjusted as to produce strips of any required width. Suppose, for example, it were required to cut a slab three feet wide into one dozen strips, all of different width: a series of cutters, all of equal diameter, would be fixed upon the axle at such relative distances apart as would correspond with the width of the strips to be produced, and all the cuttings would be made at one time. One man attends to the machine, adjusting the cutters to the axle, arranging the marble on the bed, adjusting the balance-weight to the work required to be effected, and keeping up a constant supply of sand and water at the fissures which the cutters make in the marble.

The form of this machine adapting it only to make rectilinear cuts, the production of a curve requires other arrangements. We have before stated that there are two machines for cutting circular pieces of marble from flat slabs. One of these, for circles of large dimensions, consists of a flat bed capable of receiving a slab six or eight feet in diameter, in a horizontal position. Above this is a vertical pillar, to the lower end of which are attached four arms at right angles with one another, and all exactly equal in length. To the bottom of each arm is fixed a piece of iron, such as the saws are made of, bent into a curve corresponding with the curvature of the circle to be produced. These pieces of iron are capable of being fixed at any distance from the centre, and the distance chosen in any particular instance depends on the diameter of the circle to be cut. When the arms revolve, the pieces of iron attached to their lower surfaces become cutters: each is capable of making a circular cut in the surface of the marble during one rotation, and all acting in conjunction to produce a more speedy effect. The slab is fastened down to the bed with plaster of Paris, to keep it from shifting during the process of sawing; and the fissure is kept constantly wetted with sand and water by a man or boy in attendance on the machine. The revolving arms are connected with a balance-weight in such a manner that the cutters sink in proportion as the fissure in the marble becomes deeper, until at length a circular piece is entirely cut out of the slab. We saw two beautiful variegated marble table-tops, about six feet in diameter, which had been cut to the circular form by this machine.

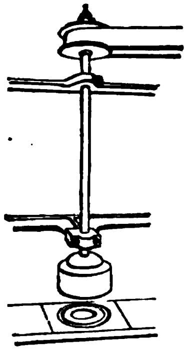

Fig. 4.

The smaller circular cutter acts on somewhat the same principle as the larger. A vertical shaft is set in rotation, to the lower end of which is attached a hollow cylinder of sheet-iron. The lower edge of this cylinder acts as a cutter, the marble to be cut being placed on a stand or bench immediately beneath it. Cylinders of different sizes are kept for circles of varying diameters, and their depth is such that three or four pieces of marble might be laid one on another, and all cut at once. The same means of fixing the marble to the bench beneath, of supplying the fissure with sand and water, and of elevating and depressing the cutters, are adopted in this as in the other machines lately described. Some years ago a contrivance, bearing a certain degree of resemblance to this, was devised for forming round pillars and hollow cylinders and tubes of stone, the cutting instrument in both cases being a cylinder of metal. By a small circular cutter of this kind, pieces of marble may be cut in great number, and with great accuracy, for mosaic or tessellated pavements.

But a mere circle, with a plain edge, is only one of the forms in which a curved piece of marble is required for ornamental purposes. The edge itself, or portions of a pillar or pedestal, may be required to present some architectural form, such as squares, rounds, hollows, &c. To give this form to a piece of marble a lathe is employed, differing little from the common turning-lathe. A small block of marble in a rough state, or a small circular piece of slab, as the case may be, is attached to the lathe, and set into rapid rotation by a shaft connected with the steam-engine; and a workman proceeds to give it the required form. This he effects—not with an iron cutter used with sand and water, nor with a mallet and chisel,—but with long sharp-pointed instruments of steel, the points of which he brings in contact with the stone in the same manner as the turner uses his chisel. The stone flies off in small fragments by the use of the sharp-pointed instrument; and when a rough approximation to the shape has been thus produced, other tools, such as gouges, &c., are employed to complete the form of the piece of marble. Pillars and other articles of a similar kind could be worked by similar means.

A few paragraphs back we described a machine called a 'ripping-bed,' by which a slab of marble could be cut up into strips. The strips thus produced are sometimes used in their plain form, after being polished; but they are more frequently diversified with mouldings, in a manner exemplified by the upright sides of a marble chimney-piece. These mouldings are worked by an ingenious machine called a 'moulding-bed,' bearing a good deal of resemblance to the 'ripping-bed,' so far as regards the flat table on which the marble is laid, and the position of a revolving axle a little above the table. But the cutters by which the mouldings are wrought are altogether different: they consist not of circular pieces of sheet-iron, but of masses of iron whose circular surfaces have been wrought into various forms, the counterparts of the different mouldings to be produced. We saw several hundreds of these cutters, adapted for all the various patterns likely to be demanded. When a strip of marble is to be moulded to any particular form, an iron cutter corresponding with that form, or rather,

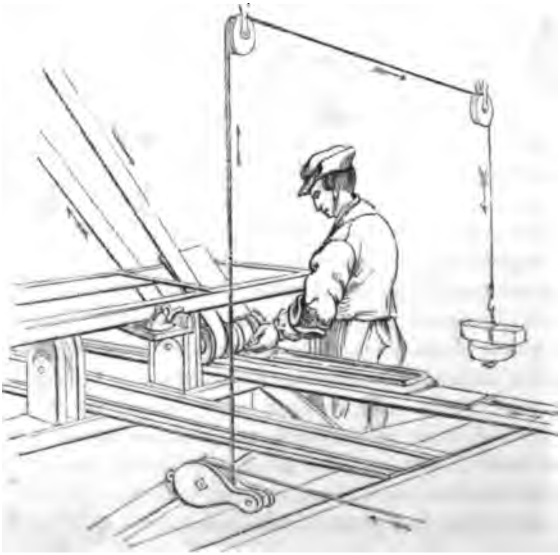

Fig. 5.

the counterpart to it, is placed on an axle just above the bed of the machine, and firmly fixed in its place. The strip of marble is then fixed down with plaster of Paris to a board which is capable of being moved slowly forward by a rope and pulley, as in the other machines, at such a height as shall just allow the iron cutter to make the required depth of cutting. The cutter being set into rapid rotation, the marble is brought up to it, and is cut or ground away by the action of the revolving iron. The marble advances onwards as fast as it is cut, and then presents a series of parallel mouldings on its surface, the counterpart of those in the cutter.

We have now, we believe, described all the machines whose action is to cut the blocks of marble into smaller pieces of various forms, and have next to speak of those whose office is to give a smooth and polished surface to the pieces so cut. The action of the cutters, whatever be their form, necessarily leaves a certain degree of roughness of surface; and if the cutting be made irregularly, the surface is not only rough, but uneven. Under all circumstances, therefore, a slab or piece of marble requires to be ground after it is cut. The means of effecting this at the marble-works are various, according to the size of the slab to be operated on. If the slab be large, a 'grinding-bed,' situated near

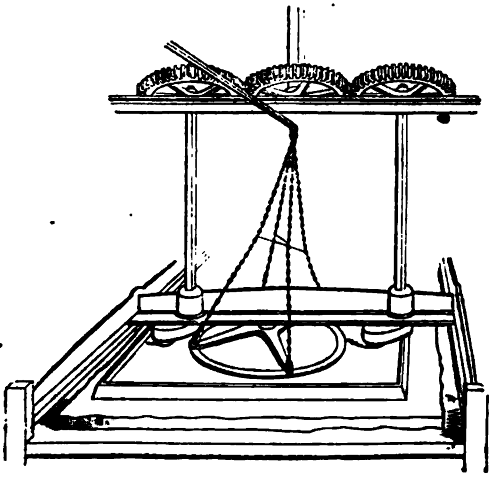

Fig. 6.

the large sawing-frames, is employed. This consists mainly of a very strong wooden bed or table on which the slab is laid, and of a large cast-iron plate whose lower surface performs the grinding process. The bed is subject to a very slow reciprocating or backward and forward motion, by means of rack and pinion work beneath; while the iron plate which is suspended from above has a very singular motion given to it, not exactly either circular or rectilinear, but a compound of both. The combination of these movements in the bed to which the marble is attached, and in the iron plate which is superposed on it, is such that the motion of any one point may be compared to the curves on an engine-turned watch. The object of this very ingenious contrivance is, that every part of the slab may be ground in the same degree and in the same manner, and that the movement of the iron over any particular part of the surface of the marble may be as varied in direction as possible. This process, like that of sawing, requires a supply of sand and water to aid the action of the iron. The supply is effected in a curious manner. The plate is surrounded by a raised ledge, and is pierced in various parts with round holes. It thus forms a kind of shallow box with a perforated bottom; and being filled or partially filled with moistened sand, the latter finds its way down through the holes, and moistens the whole surface of the marble beneath the iron. The plate is capable of being elevated and depressed to different heights, to accommodate the thickness of the marble which may be placed beneath it.

The machine thus described is particularly calculated for grinding large flat surfaces of marble, which it reduces to a plane almost mathematically correct. But for smaller pieces of marble, or the edges of slabs, another machine is employed, in which the grinding instrument, although arranged in a totally different manner, is still made of iron. A circular plate of iron, about five feet in diameter, and two inches in thickness, is placed in a horizontal position, and connected with a vertical shaft or axle, which passes through the centre. This axle, by the aid of intervening wheel-work, is set into rotation, and in its turn rotates the iron plate. The lower surface and the edge of the plate are hidden, but the upper surface is open; and being at a height of about three feet from the ground, it forms a convenient bed or bench, at which the men may work: it is in fact an iron workbench revolving in a horizontal direction. This 'circular grinding-bed,' which the workmen—with the peculiar nomenclature of which most workmen

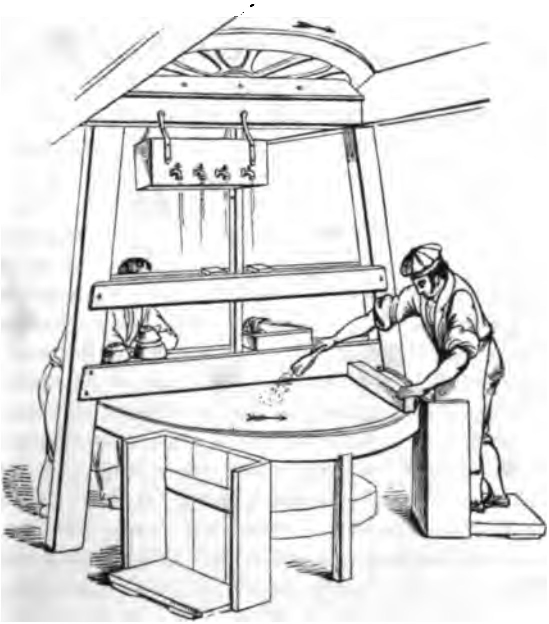

Fig. 7.

are so fond—call a 'roundabout,' is moistened with sand and water; and any pieces of marble which are to be ground by its aid are pressed down firmly upon it. The iron surface has the same effect on the marble in this instance as in the former, the difference being in the kind of motion given to the iron, and in the iron being beneath the marble instead of above it.

The action of a surface of iron, used as in the two machines just described, is not to polish the piece of marble exposed to it, but merely to bring it to a perfect level, by removing all saw-marks and other irregularities of surface. But as one of the chief beauties for which marble is admired is the brilliant gloss presented by its surface when highly worked, the slabs or strips, after being ground by one of the two machines described above, are carried to a polishing machine, or 'polishing-bed,' situated in the upper floor of the building. This machine is about twelve feet long, four or five wide, and three high. It

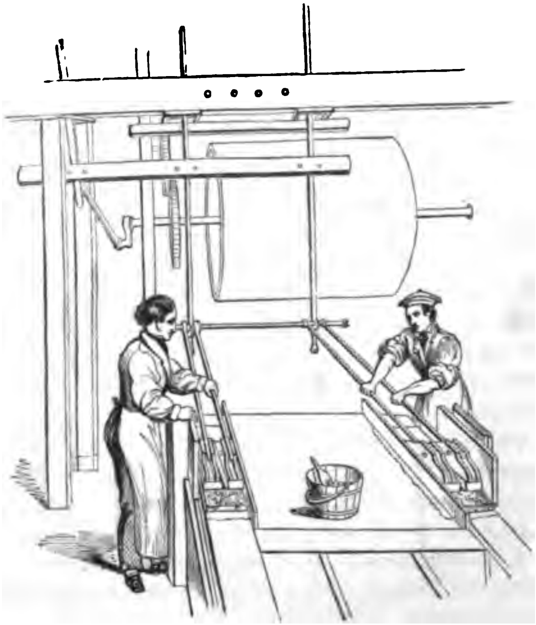

Fig. 8.

consists of a flat bed on which the piece of marble is laid, and mechanism for working the polishing instruments. Each of these latter is about two feet long and four inches wide, formed of lead or some other heavy substance, and faced at the bottom with a layer of a peculiar kind of felt, adapted for the polishing of marble. Each polisher is connected by means of a long handle with the working machinery of the steam-engine, by which it acquires a backward and forward motion over the surface of the marble; and the arrangement is such that several polishers may be wrought at one time. All flat surfaces of marble, whether large slabs or narrow strips, may be polished in this way.

There are, in most worked specimens of marble, whether articles of furniture or of decoration, numerous small pieces which cannot be conveniently or profitably prepared by the machines which have lately engaged our attention. This is especially the case where any elaborate carved work forms part of the design. It thence results that there are a large number of men employed at the Marble-works besides those who are in attendance on the machinery. A brief notice of the modes in which the manual labour of these workmen is applied will be a necessary sequel to our preceding details.

If a small piece of marble is to be cut in a manner which does not require the aid of the machines, a man uses a kind of small hand-saw, formed, like the larger saws, of a piece of soft iron without teeth. This piece of iron is fixed into a handle, and it is used nearly in the same manner as a common saw; the workman keeping the fissure in the marble constantly supplied with sand and water. The process of grinding small pieces of marble by hand is in like manner a miniature representation of the analogous process as effected by machinery. Small pieces of iron, attached to wooden handles of a convenient shape, constitute the grinding tools, which are used with sand and water.

The chisel and mallet are tools of which we have not had much occasion to speak; but they are much used in the finer and ornamental parts of the work. This is often very slow and tedious work. The piece of marble to be carved is placed upon a bench; and the workman, provided with chisels, gouges, and pointed instruments of various shapes, chips away the marble until he has formed the required device or pattern. Foliage, groups of figures, and indeed all patterns in which varying undulations of surface occur, are produced by these means. We saw, under process of carving, several elaborate balusters of black marble for a staircase at Hamilton Palace. Each baluster was about a yard in length, and five or six inches in thickness, and profusely decorated in every part. One piece of marble, without joint or division, formed each baluster; so that the carver had to chisel away just enough, and no more, to produce the required pattern. The beautiful substance of which these balusters were formed suggests a remark on the store of material which we have in our own country and in the sister island. This black marble, brought from a quarry near Galway, is perfectly spotless, as black as jet, and susceptible of a very high polish; and as the blocks procurable from thence are among the largest which have ever been brought to England, the marble is capable of being applied to a great variety of purposes. A visit to the British Museum will show that our quarries are capable of supplying black and coloured marbles of great beauty. In the New Mineralogical Gallery are two tables, one presented to the Museum by Mr. Martin, and the other in 1838 by the Duke of Rutland. The former consists of a richly variegated green and white serpentine marble, brought from the quarry of Ballinahinch, near Galway. The latter consists of two kinds of marble, the frame-work, legs, and bottom plinth of the table being of black marble, brought from Bakewell in Derbyshire, and the top being composed of a very curious sponge-coloured slab of stalagmitic marble from Hartle in the same county. If the means were attained for working up these fine marbles in an expeditious and economical manner (and the patent machinery seems calculated to aid in producing this result), the more extensive use of our home quarries would in all probability follow.

All the pieces of marble which have passed through the hands of the carver require to be ground and polished before the beauty of surface can be developed. This is effected by using small pieces of different substances, such as cast-iron, gritstone, smooth stone, and slate, shaped so as to suit the diversities of ornament, and rubbed over the marble until the latter is brought to a fine surface. These are processes which it is not probable machinery will ever be made to perform. Instead of expressing any surprise at this circumstance, we cannot but admire the ingenuity which could effect so many different processes by machinery: the cutting of slabs from the block; the cutting of strips from a slab; the cutting of various-sized circles; the cutting of architectural mouldings in a slip of marble; the grinding of a large slab by one machine, and of small pieces by another; the polishing of the pieces thus ground; and the adjustment of machinery by which all these processes are performed through the agency of one working shaft of the steam-engine—required no small share of inventive talent.

In conclusion we may say, that if a visitor is resolute enough to bear the "setting his teeth on edge" by the noise of the sawing, there is much to interest him at this establishment.

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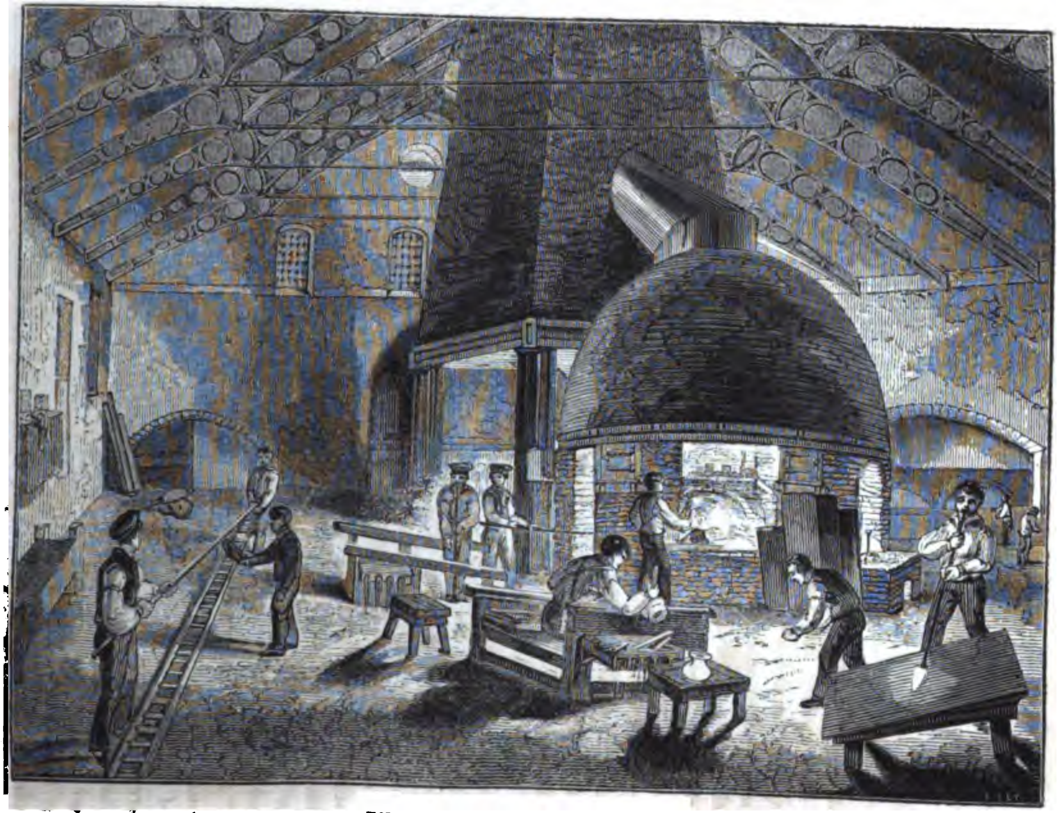


XII.—Glass-blowing Furnace.—Face p. 257.

XII.—A DAY AT A FLINT-GLASS FACTORY.

"It might contribute to dispose us to a kinder regard for the labours of one another, if we were to consider from what unpromising beginnings the most useful productions of art have probably arisen. Who, when he first saw the sand or ashes, by a casual intenseness of heat, melted into a metalline form, rugged with excrescences and clouded with impurities, would have imagined that in this shapeless lump lay concealed so many conveniences of life as would, in time, constitute a great part of the happiness of the world? Yet, by some such fortuitous liquefaction was mankind taught to procure a body, at once, in a high degree, solid and transparent; which might admit the light of the sun, and exclude the violence of the wind; which might extend the sight of the philosopher to new ranges of existence, and charm him, at one time, with the unbounded extent of material creation, and at another with the endless subordination of animal life; and, what is of yet more importance, might supply the decays of nature, and succour old age with subsidiary sight. Thus was the first artificer in *glass* employed, though without his knowledge or expectation. He was facilitating and prolonging the enjoyment of light, enlarging the avenues of science, and conferring the highest and most lasting pleasures: he was enabling the student to contemplate nature, and the beauty to behold herself."

A century has nearly elapsed since Dr. Johnson wrote this forcible and beautiful paragraph; and nothing has occurred, in the subsequent history of manufactures, to lessen its truth or beauty. Many opaque substances are capable of assuming a form more or less vitreous or glass-like; such as earths, some acids and salts, and metallic oxides. In porcelain we see an example of partial vitrification; for the granular texture is exceedingly fine, and a slight translucency is produced. But complete vitrification never results until after the fusion or melting of the ingredients; and we know of no means by which porcelain clay or any other earth may be melted in its simple state. But when two kinds of earth are mixed together, or, still better, when a siliceous earth is mixed with certain crystalline salts, perfect fusion may be produced, and a nearer approach to transparent glass may result. Again, some of the metallic oxides may be made to assume a vitreous form, and, when mixed with silex, to produce a glass possessing valuable properties. We may thence regard glass, generally speaking, as resulting from the mixture and fusion of these three kinds of ingredients; and the purpose fulfilled by each may be thus understood:—the siliceous substance is the vitrifiable ingredient; the salt or alkali is the flux, by mixture with which the silex becomes fusible; and the metallic oxide, besides acting as a flux, imparts certain qualities whereby one kind of glass is distinguishable from another.

Such is the nature of vitrification, a process which, if we may judge from the researches made within the last thirty or forty years in Egypt, and the discovery of the mode of deciphering the hieroglyphics so profusely displayed on Egyptian monuments, was known in very remote ages. Sir J. G. Wilkinson ('Manners and Customs of the Ancient Egyptians') adduces three distinct proofs that the art of glass-working was known in Egypt before the exodus of the children of Israel from that land, three thousand five hundred years ago. At Beni Hassan and at Thebes are paintings representing, in a very rude form, glass-blowers at work; and from the hieroglyphics accompanying them, it is found that they were executed in the reign of a monarch who occupied the throne at about that period. Again: images of glazed pottery were common at the period under consideration, the vitrified material of which is of the same quality as glass; and therefore the mode of fusing, and the proper proportions of the ingredients for making glass, must have been already well known. Lastly, Sir J. G. Wilkinson adduces the instance of a glass bead about three-quarters of an inch in diameter, which Captain Henvey found at Thebes, and which contains in hieroglyphic characters the name of a monarch who lived fifteen hundred years before Christ.

The knowledge of the manufacture probably travelled from Egypt to Greece, and thence to Rome and modern Europe; and successive improvements have not only brought the art to a high degree of excellence, but have led to its subdivision into several kinds, such as flint-glass, plate-glass, window-glass, and green or bottle-glass making.

Confining ourselves to flint-glass, we now invite the reader's atten tion to the process of manufacture. The flint-glass works of Mr

Pellatt, which we have been permitted to visit for our present purpose, are situated in Holland Street, Blackfriars, and comprise the various buildings necessary for the production of flint-glass ware: such as a horse-mill, for grinding old melting-pots, as one of the ingredients in the manufacture of new ones; a room wherein ground or powdered clay is mixed and kneaded into a working state; another in which the pots are made; others for drying the manufactured pots; rooms for storing, washing, and preparing the alkaline salts; others for washing and drying the siliceous sand; a mixing-room, wherein the sand, alkali, and oxides are combined; two coking-ovens, or furnaces for converting coal into coke; the glass-house, with its working furnaces, pot-furnace, and annealing-oven; glass-cutting and glass-engraving shops; and others for subsidiary purposes: the whole occupying an area of about three-fourths of an acre. The routine of operations in these departments will come successively under our notice.

In describing the vitrifiable qualities of various materials, we used the most general terms, in order to include all kinds of glass within our remarks; but it is necessary now to state the restrictions which are required in practice. Although most earthy substances may, by peculiar treatment, be wholly or partially vitrified, yet *silex*, or *flint*, is that which possesses the most valuable qualities. Again, although many alkaline and saline substances might be used as fluxing materials, yet *soda* and *potash*, in one or other of their forms, are those generally employed by the glass-maker. Lastly, although many metallic oxides might be similarly vitrified, yet *oxide of lead* is that which is most frequently employed. This being premised, we may state that the materials for flint-glass are nearly as follow:—One part of alkali (carbonate and nitrate of potash), two parts of oxide of lead, three parts of sea-sand, and a minute portion of the oxides of manganese and arsenic.

The term 'flint-glass' is given because flints were formerly employed as the siliceous material: they were made red-hot, and plunged into cold water, whereby they were so fractured and disintegrated as to be easily ground to powder. Sea-sand is, however, now found to answer the same purpose, at a less expenditure of time and trouble. The sand employed is obtained from the seashore at Lynn in Norfolk, and at Alum Bay, Isle of Wight, the qualities brought from hence being superior to most others. A few years ago, a portion of sand brought from Australia as ballast was found to answer the purpose of

English sand, and was indeed expected to be superior: we believe, however, that the qualities of the three kinds are now ranked nearly on a level.

The sand, being impure when brought to the works, is conveyed to an upper room, and thrown into a trough containing water. This trough is capable of being closed, and is fixed on horizontal pivots, whereby a rocking motion can be given; and the sand, being thus driven from side to side in the water, and stirred with a spade, loses some of its impurities. The dirty water is emptied into a channel in the floor of the room; and the same process is repeated seven or eight times until the sand becomes perfectly clean. It is then placed in a trough over an oven, through holes in which it passes, when partially dried, into the oven beneath, and, when dried, leaves the oven in the state of fine, glittering, white particles.

With regard to the alkali employed, there are reasons why potash, in the form of carbonate, is preferable to other kinds; the carbonic acid being, however, dissipated during the melting, and leaving the potash in a pure state. The carbonate of potash is obtained from Canada and the United States, and requires a process of washing previous to use. It is conveyed to an underground apartment, in which are washing-bins, settling-pans, evaporating-pans, and other necessary apparatus. The state to which the carbonate is brought by the process of cleansing is that of fine white grains, differing but little, to an unpractised eye, from the prepared sand.

Oxide of lead, both in the form of litharge and of minium, or red-lead, is employed in flint-glass for the following reasons:—it is a powerful flux, enabling the sand to melt more readily, and it gives the glass greater density, greater power of refracting light, greater lustre, greater resistance to fracture from sudden heat and cold, and greater ductility during the working. If there be too much of this material, the glass becomes inconveniently soft.

The other ingredients in flint-glass, which are very small in quantity, are used as purifying and bleaching agents; and, as well as the oxide of lead, require but little preparation on the part of the glass-maker.

Let us assume that these several ingredients are in a sufficiently prepared state. They are taken to the 'mixing-room,' which contains several long bins or boxes; and after being weighed in proper proportions, the ingredients are sifted, mixed in the bins, and brought to a state fit for the melting-furnace. Here we must leave them for the present, remembering that the state in which the ingredients are put into the melting-pots is that of a salmon-coloured powder, the red tinge being given by the oxide of lead.

The melting-pots, and their mode of preparation, now deserve our notice. The reader will not be surprised to hear that the manufacture, drying, and baking of the glass-pots are important processes; since one pot, when filled, contains sixteen hundredweight of glass, the preservation and proper melting of which are essential to the subsequent labours of the glass-worker.

There is a particular kind of clay, brought from Stourbridge in Worcestershire, which seems better calculated than any other as a material for the glass-pots, and which is dug from the soil in a hard state, ground fine, barrelled, and sent up to London. The broken or worn-out pots are likewise found to be useful when employed in combination with new clay; four parts of new clay being mixed with one part of old pots, ground by a horse-mill, and sifted to fine powder. The mixed ingredients then undergo a process so primitive, that one almost regrets to see it in this age of machinery. The powdered clay, being mixed with warm water in large square leaden troughs, is trampled on with naked feet until thoroughly kneaded into a stiff adhesive clay. The kneading of the dough for sea-biscuits at Deptford, which was formerly done by men's fists and elbows, is now much better effected by machinery; and we might suppose that a similar result would follow the application of machinery in the present case; but it appears that a machine, formerly employed at these works for this purpose, failed to produce the required effect, and the old method was again resumed.

The services of the 'pot-maker' are now called for. The melting-pots for flint-glass are not moulded, but are built up piecemeal, each piece being rolled into a cylindrical form, and laid in a curve on preceding rolls. If we could imagine a boy's grotto to be built of these clay rolls instead of oyster-shells, we might form an idea of the potter's operations, with this important addition, that every roll of clay is so thoroughly pressed and squeezed as to expel all the air from between the rolls, and to form a uniform and thick wall or crust. The manipulations of the potter are aided by a few simple tools; and, keeping four pots in progress at once, working a little on each in turn, he completes the four in six days. Few persons, probably, on hearing of a 'melting-pot,' would imagine the weight and bulk of those here alluded to. The weight of clay required for one pot is nearly one thousand pounds; and the dimensions of the finished vessel are about three feet in height, two and three-quarters in diameter, and from two to three inches thick. The shape is nearly cylindrical, with a hemispherical top and a flat base, and there is only one opening, about eight or ten inches in diameter, at the upper part of one side.

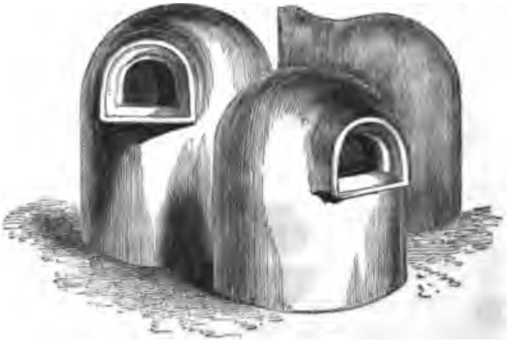
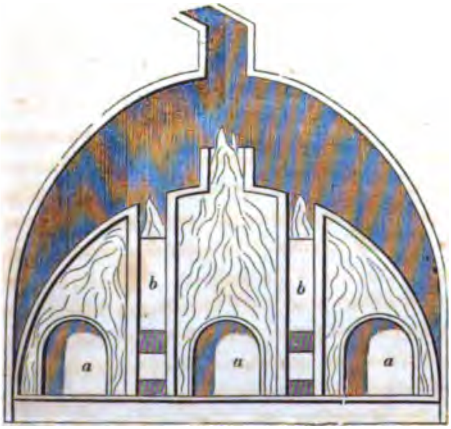


Fig. 2.

The longer these pots can be left before they are used, the better; consequently it is important to keep a considerable number on hand. We were struck with the singular appearance of a large dark room, the floor of which was studded with nearly a hundred of these dome-shaped vessels. A little stretch of imagination would have transformed the assemblage into Cassim Baba's oil-jars, and have peopled them with forty (or twice forty) thieves; but the damp odour of clay kept the thoughts from wandering from Blackfriars to Bagdad. The pots are left in this room for several months. The evaporation from the damp clay is considerable, and is allowed to go on very gradually, in order to ensure an equable state throughout the thickness of the pot. When the drying is effected, the pots are taken as wanted to an adjoining room, kept at a higher temperature, and then, a door being opened into the glass-house (of which more presently), each pot is lowered by a crane, and placed in the 'pot-arch.' This arch is a small furnace capable of containing two or three pots; and the pots are there exposed for five days to a very intense heat.

The ingredients are prepared; the melting-pots are made and hardened; and it is now time to visit the 'glass-house' itself—the part of the building to which all the others are subsidiary, and to which the eye of an artist might be directed for some striking effects of light and shade. Imagine a large room, fifty or sixty feet square, with an earthen floor bounded by brick walls, lofty and dimly lighted, and covered by an iron roof, the middle of which is probably fifty feet from the ground. This is the shell or crust, the kernel of which is the melting-furnace. In the middle of the room we see four pillars, twelve or fourteen feet high, supporting the four corners of a great chimney, which passes through the middle of the roof, and rises to a height of about eighty feet. This chimney is quadrangular, tapering upwards; and a clear passage is left beneath it between the pillars. Built on the level of the ground, at two opposite sides of this chimney, are two furnaces, the smoke from each of which ascends by a bent flue into the great chimney. Such are the objects which first meet the eye through the dusky gloom of the place.

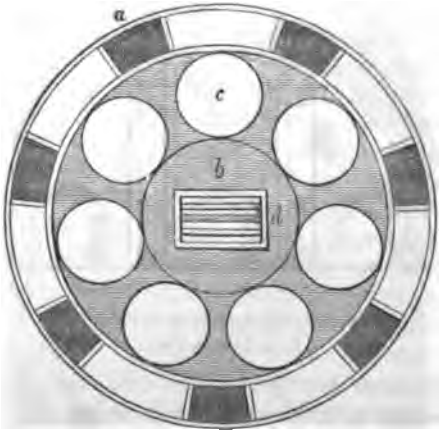


Section of Melting-furnace.—Fig. 3.
a, the pots; *b*, flues.

As the two furnaces closely resemble each other, we will, for convenience of description, speak as if there were but one. Each furnace is a circular dome, about fifteen feet in diameter and the same in height; and its internal construction may be understood by supposing two basins, one shallow and the other deep, to be inverted and placed one on another, the shallower one underneath. The inner basin encloses a space containing the pots, the fuel, and the flame and smoke arising therefrom; this flame and smoke reverberate from the vaulted roof, and pass up through flues into the cavity between the two basins, whence the smoke passes, by a bent pipe, into the chimney. All is constructed of brick, and lined with clay capable of resisting the fiercest heat.

The fuel for this furnace is laid on an iron grating in the middle, in connection with which, and beneath the glass-house, is a series of passages running in various directions to the extent of some hundred feet, and intended to furnish the channels for a powerful draught, which, passing upwards through the grating, keeps the fuel in an intensely ignited state. The roof of the inner dome of the furnace is about five or six feet from the ground; and the flame and heated air, reverberating from this roof, maintain a very high temperature within the internal area.

Formerly, the fuel employed used to be coal, but it is now found that in London many advantages result from employing oven-burned coke instead. In a distinct part of the building two coking-ovens have been erected for the purpose of preparing the coke on the premises. Into



Ground Plan of Melting Furnace —Fig. 4.
a, flues; *b*, seague or ground on which the pots, *c*, are placed; *d*, grate-bars.

these ovens, which are nearly circular and very shallow, is put small coal, such as is brought from the pit-mouths in Northumberland; and after twenty-four hours' burning or roasting, during which the inflammable matters are driven off, the fuel is drawn out in the form of coke. The quantity of coke producible from a given weight of coal depends principally on the kind of coal employed: in the present case it is in about the proportion of five to seven.

The melting-pots being of large dimensions, openings or arches of sufficient size are left in the sides of the furnace, to allow of the pots being introduced; after which the openings are bricked up. A pot, when once introduced into the furnace, is seldom removed until worn out; but as the average duration of a pot is not more than two or three months, these removals frequently occur. The withdrawal of an old pot and replacing it with a new one is called 'setting a pot,' and constitutes the most arduous and indeed fearful operation of the glass-house, and the one to which the men are wont to refer as proof of their power of heat-endurance. It frequently happens that the old pot breaks, and the pieces, becoming partially vitrified, adhere to the bottom of the furnace: in such case the men stand in front of the fiercely-heated openings, and dig up and remove the broken fragments of pot by means of crow-bars and other instruments. While the removal of the old pot is in progress, the new one is kept at a white heat in the 'pot-arch,' a pot-furnace within a few yards of the melting-furnace; and when the transference is to take place, the door of the arch is opened, a low iron carriage is wheeled in and tilted so as to lift up and draw out the pot, and the latter, at a glowing white heat, is wheeled to the furnace, and there deposited in its proper place. When the adjustment is properly made, the opening is immediately bricked up. The temperature to which the men are exposed in this operation (which sometimes takes several hours) may be imperfectly imagined when we remember that the other pots in the furnace may at that time be at a perfectly white heat.

In some kinds of glass manufacture, open melting-pots are used, whereby the fusion of the ingredients is effected in a shorter time. But flint-glass is liable to be injured by the carbonaceous and gaseous matters arising from the fuel, and therefore the pots are covered in. Each pot is so placed in the furnace that the mouth shall be directed outwards; and this projecting mouth is so bricked and clayed round as to prevent the escape of flame. By this arrangement, every part of the pot, except the mouth, is surrounded by a fierce heat; and although, on looking through this orifice from without, a fiery whiteness is seen, yet this results from the interior of the pot, and not from the interior of the furnace itself, the latter being entirely shielded from view.

Such is the melting-furnace, provided in this way with seven pots; and we now follow the routine of processes connected with the melting.

The management of a glass-house, in respect to *time*, is somewhat curious and worthy of note. The filling and emptying of a melting-pot are in general so managed as to occupy one week. On Friday morning the necessary arrangements for filling commence. The mixed ingredients are brought to the furnace in wooden vessels, and then thrown into the pots by means of shovels, through the openings before alluded to. About four hundredweight is put into each pot; the mouth is closed; the fire kept burning strongly; and the ingredients allowed to sink and melt. Three or four hours afterwards, the hole is again opened, another equal supply thrown in, and another equal space of time allowed to elapse. This is repeated four times, until each pot contain its full quota of about sixteen hundredweight. When all the pots are filled, every orifice is stopped up, the fuel is urged to vivid combustion by increased draught from beneath, and the ingredients remain throughout Saturday and Sunday exposed to an intense heat. At stated intervals a small opening is made, and a little of the 'metal' (as the glass is technically termed) is withdrawn to test its progress. In some glass-works, a considerable quantity of scum rises to the surface of the glass while melting; but there is not much in a flint-glass furnace, on account of the purity of the materials, and this little is removed by skimming. We may here observe, that without any wish on the part of the proprietor to deviate from usual customs, a glass-house furnace must necessarily be kept heated on Sundays as well as other days; but the week is so apportioned as to leave as little as possible to be done on Sundays—nothing, indeed, but to watch the furnace, each man having three Sundays out of four at liberty.

On Monday morning all is ready for the glass-workers; the pots are full of 'metal,' looking like liquid fire, and a large party of workmen assemble round the furnace. The mouths are opened, so as to afford access to the melted glass; and smaller holes are opened also, at which the working-tools are heated.

Flint-glass ware, such as drinking-glasses, cruets, decanters, lustres, lamp-shades, phials, &c., are made partly by blowing, partly by manual working, and, in a smaller degree, by moulding or casting, in a way which we will endeavour to describe. We first saw some four-sided perfumery bottles made. A man took a hollow iron tube, about five feet long and half an inch in diameter, and, dipping one end into a pot of melted glass, collected a small quantity at the extremity. The glass appeared like a projecting lump of red-hot iron, and, from its consistence (between that of treacle and of putty), was just able to be retained on the tube. He then rolled the glass on a flat plate of iron, thereby giving it a cylindrical form, and pinched a part of it, by means of a small instrument, to form the neck of the bottle. He next inserted the end of the tube into a small brass mould lying on the ground, shut up the two parts of which the mould consisted, and blew through the tube. This double operation produces a curious effect; for while the air from the lungs, passing through the tube, makes the mass of glass hollow, the mould at the same time imparts to it the external form required. The mould being opened, the glass—now in the form of a bottle—was withdrawn, still adhering to the end of the rod, and was detached by a slight touch with a piece of cold iron. All this was done in about half a minute; and during the latter part of the process another workman was gathering and rolling a similar portion of glass, so that one mould served for both. As the bottles were severed from the tube, they were taken up on the end of a heated rod by a third workman, who re-heated them (for by this time they were below red-heat), and by means of a few simple tools finished the necks and mouths as fast as the other two could make the bottles. Fig. 5 represents the bottle-maker, and Fig. 6 one form of mould used by him.

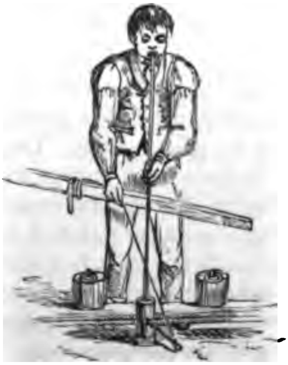


Fig. 5.

A far more skilful operation was the production of a claret-jug, since no part whatever of this vessel was moulded. The workman, with a heavier tube than the one before alluded to, gathered a considerable quantity of metal; whirled it twice or thrice round his head, to

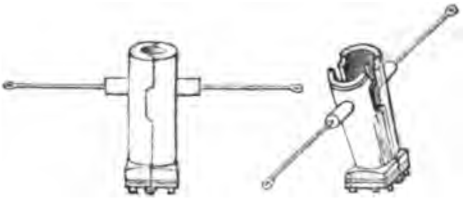


Fig. 6.

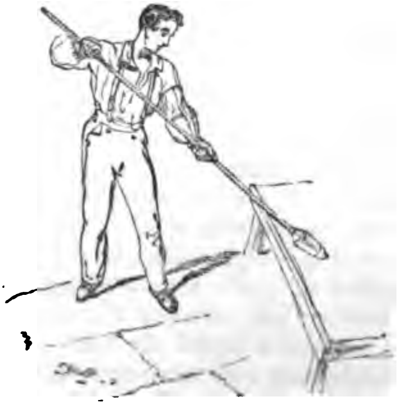


Fig. 7.

elongate the mass; rolled it (Fig. 7) on a flat iron plate to give it a regular shape; and blew through the tube from the other end (Fig. 8), to make the glass hollow. The rolling and blowing having been repeated two or three times, another workman received it, and sat down in a chair having two flat parallel arms sloping downwards. Then, resting the tube on these arms, he rolled it backwards and forwards, to keep the glass from bending; and a boy stooping down at the other end, blew through the tube, whereby the mass of glass was maintained hollow. By the aid of an elastic instrument, shaped nearly like sugar-tongs, the workman brought the mass into form (Fig. 9), rolling the tube continually, and heating the glass frequently to preserve the proper consistence. Another workman, called the 'footer,' then brought a little melted glass on the

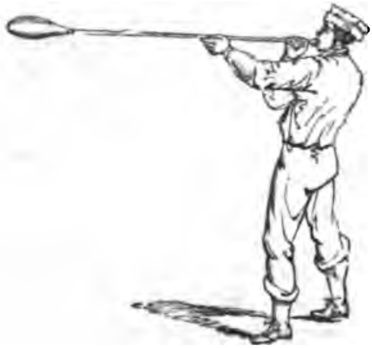


Fig. 8.

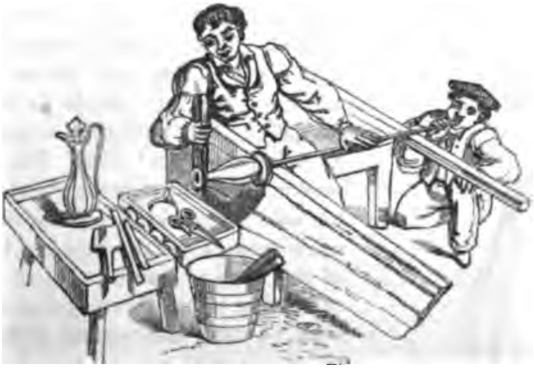


Fig. 9.

end of a rod, and applied it to the end of the blown mass, to which it instantly adhered. This was soon shaped into a foot; and the whole was transferred from the tube to a rod called the 'punty,' the latter being made to adhere to the foot of the vessel by a little melted glass, and the tube being detached by a touch with a piece of cold iron at its junction with the glass. The glass thus transferred, the making of the upper part of the vessel proceeded. With the aid of scissors, a piece of glowing glass was cut off, so as to allow of a depression for the lip of the jug, and the edge was bent and curved with a dexterity altogether beyond the scope of description. Sometimes one prong, sometimes both prongs of the tongs were inserted in the mouth of the jug, and the internal cavity, as well as the external surface of the jug, were gradually modelled into shape. An attendant workman next brought a smaller mass of melted glass on the end of another rod, which was attached to the vessel, and curved in the form of a handle by a few delicate manœuvres.

The rapidity with which these operations are effected almost baffles the eye of the spectator. The glass is in such a medium state between a solid and a liquid, that while, on the one hand, it would drop from the tube if not kept rotatory, it is, on the other, capable of being pulled, twisted, stretched, cut, pressed, and worked in various ways. No mould, stamp, or press was employed in the manufacture of this jug, the whole being effected by the manual dexterity and accurate eye of the workman, aided by a few of the most simple tools. Great, indeed, is the surprise excited at seeing such an elegantly-formed vessel manufactured in such a way in the space of ten or twelve minutes: we here allude to the making only, for in Fig. 10 the jug is represented in its finished or 'cut' state. The eye of the workman detects when the glass is becoming too cold for working, and he holds it for a few seconds at the 'working hole,'—one of the furnace-mouths. After every such re-heating, he sits down again, and rolls the tube on the 'chair-arms,' with the glass projecting over near his right hand.

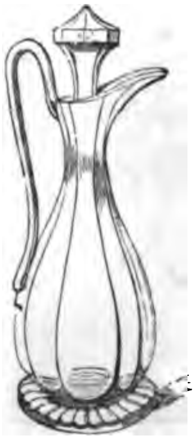


Fig. 10.

In all vessels provided with a leg and foot, such as wine-glasses, the leg is formed of one dip of glass, and the foot of another, each in turn being attached to the body of the vessel, and worked into shape. In such articles as salvers, dishes, or shallow vessels generally, the workman, after having his mass of glass hollowed by blowing, transfers it from the working-tube to the punty: the hole left where the tube had been attached he gradually enlarges, by whirling, modelling, re-heating, and bending, until the glass expands to the wide flat concave form re quired. In any vessel to be provided with a handle, a lump of glass—if we call it glass putty perhaps the reader will form a better idea of its consistence—is attached at one spot, drawn out, dexterously curved, and attached also at another spot; an operation nearly as surprising as any in the manufacture, since the workman has no guide but the accuracy of his eye in suddenly forming the handle. In such a production as a lamp or chandelier-shade, the mass requires frequent re-heating, on account of the large size attained; and whenever the mass of glass has to be thus repeatedly heated, a constant rotation is given to the tube or rod, to preserve a circular form in the article attached to it. While re-heating at the furnace, this rotation is maintained as much as on the 'chair-arms,' a resting-groove being placed in front of the furnace-mouth for the support of the rod while rotating (Fig. 11).

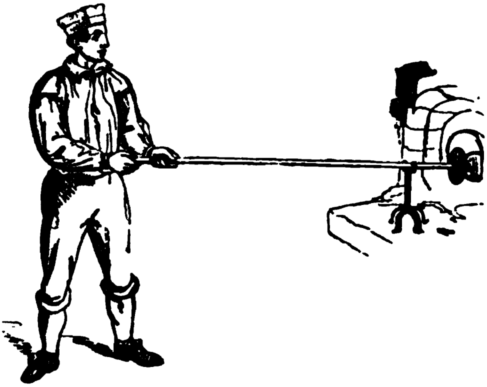


Fig. 11.

The ductility of the melted glass, or that property by which it is capable of being drawn out, is perhaps nowhere so strikingly shown as in the making of glass-tubes, such as are employed for thermometers, barometers, &c. A workman collects a quantity of glass on the end of a tube, rolls it on an iron plate into a cylindrical form, blows into it to form a cavity within, and holds it towards a second workman, who attaches a heated rod to the other end of the mass, to which it instantly adheres. The two men, standing opposite each other, then walk backwards, the glass elongating as they proceed, until a tube forty or fifty feet long is produced. This tube hangs down as it is formed, and rests on a ladder or frame laid along the floor of the glass-house; and by the time all the mass of glass is thus drawn out, a tube almost perfectly equable in thickness is formed, with a bore or perforation running through its whole length. The preservation of this bore is one of the most singular parts of the process, the elongated tube acquiring a bore of the same *form* as is given to the cavity in the mass of glass, however much reduced in size. In most thermometers the mercurial column is seen to be flattened, so as to be scarcely visible when viewed laterally. This flattened shape represents the form of the bore of the tube; and in order to produce it, the mass of glass, after having been blown hollow, is gently pressed on two opposite sides, whereby a flattening of the internal cavity is produced, while the external surface is again made cylindrical by re-dipping into the melting-pot. This form—that is, flat within and circular without—is retained throughout the subsequent elongation, notwithstanding the vast diminution in the sectional area of the tube. Most kinds of glass-tubing, for meteorological, optical, or other purposes, are produced in a manner nearly analogous to that here described, the length of tubing being afterwards cut into convenient portions. Most persons have probably seen or heard of "Glass-working exhibitions," in which trinkets and toys are made in a very delicate and neat manner out of melted or softened glass: although the glass is, in these cases, melted at a blow-pipe instead of a furnace, yet the principle by which the exhibitor is enabled to proceed is the same as that developed in tube-making, and calls for our assent to the remark, that "flint-glass possesses, at the working heat, a degree of tenacity and ductility not to be found in any other substance in nature."

Several thousand pounds' weight of glass is weekly wrought into these various articles; and we must now quit the melting furnace, to watch the manufactured articles in the process of 'annealing.' The object of this process is to render the glass less brittle, and less liable to fracture from sudden alternations of temperature. If a glass vessel, made at the high temperature necessary for working, were allowed at once to cool in the open air, the surfaces of the vessel would cool and contract more rapidly than the interior substance, whereby the glass would be in an unequable state of elasticity, and therefore liable to fracture. We have seen a piece of thick glass-tube, which had been plunged while hot into cold water; the interior surface was cracked to such a degree as to appear like a surface covered with crystals.

There are philosophical toys, known as 'Bologna phials' and 'Prince Rupert's drops,' which are similarly treated, by being plunged into cold water while yet hot: the exterior becomes cool and fixed before the interior has time to contract in a corresponding degree; the consequence of which is, that this unusual state of tension causes the whole to be shattered to atoms when the smallest incision or scratch is made on the surface. To avoid such an inconvenience as this, glass-ware is suffered to cool by very slow degrees.

This slow cooling takes place in an annealing-oven called a 'leer;' a name for which it would not, perhaps, be easy to furnish a reason, unless it be an instance of the Anglicised foreign terms used in a glass-house, and of which the 'punty,' or working-rod, and the 'marver,' or iron plate, furnish examples—these two terms being derived from the French 'pontil' and 'marbre.' The arched entrance to the 'leer' is seen at one side of the glass-house, closed by iron doors; the oven having the form of a long flat arch, sixty feet in length or depth, five feet wide, and from one to two in height. Adjoining the door of the oven on each side is a furnace, by which a high temperature is maintained; but as there is no other heating-power, the oven experiences less and less of the heat as the distance from the mouth is greater, until, at the remote extremity, the temperature is scarcely higher than that of the surrounding atmosphere. Along the floor of the oven is a miniature railway upon which two rows of iron trays, called 'leer-pans,' travel.

Such being the arrangement, and all the operations being in full play, the annealing proceeds as follows:—As soon as a glass vessel is formed, a boy carries it, either on a wooden shovel or by means of a pronged fork, to the 'leer,' and places it in one of the pans. This continues until one pan is full; and the pan being then wheeled onward by means of a windlass, another is laid in its place, similarly filled, and similarly wheeled on; and so on, one pan after another. By this means the pan first filled is drawn farther and farther from the heat, whereby the annealing or gradual cooling is effected. The time required for annealing varies from twelve to sixty hours according to the thickness of glass in the article manufactured; and matters are so arranged as to have similar articles in the oven at one time, in order that the same routine may be available for all; or else to make the two rows of pans travel with different speed. There are some annealing-ovens in which the process is differently conducted: they are much shorter, and more equably heated in the different parts; and after being filled with manufactured articles, the mouth is closed, and the fire allowed gradually to go out, whereby the whole oven loses its heat by slow degrees. The form first described is, however, found most advantageous in the flint-glass manufacture.

The order of processes now requires us to visit a room at the remote end of the annealing-oven. The key of this room is in the possession of an excise-officer, under whose supervision all the arrangements of the room are conducted. Were this the place, we might remark on the evils resulting to manufactures from the mode in which excise duties are collected on the articles manufactured; but we must take the case simply as we find it. The annealed vessels are removed from the pans, examined to see that they are perfect, and weighed, a duty being payable on such articles only as leave the annealing-oven in a perfect state. This restriction is necessary, for the vessels are frequently spoiled in the oven, either by being imperfectly annealed, or by being over-heated near the furnace.

Many articles of flint-glass ware are deemed finished when they leave the annealing-oven, and are accordingly warehoused; but the brilliant display of a sideboard or dinner-table owes much of its attraction to the cut, or, if the term be allowable, sculptured forms of the glass vessels. This cutting is effected after the vessels are annealed, in a distinct part of the building, and by a process wholly different from those hitherto described.

The glass-cutting room has a singular appearance. A double workbench extends along the room, divided into several compartments for an equal number of men. In front of each workman is a thin wheel revolving on a horizontal axis; and above some of the wheels are vessels containing sand and water, which drop through a small orifice in the bottom, and fall on the edge of the wheel. All the wheels are set in motion by steam-power, and each workman has the means of unfixing his wheel, and putting on another of a different kind. These wheels are of various sizes, and made of various substances, such as cast-iron, wrought-iron, Yorkshire stone, and willow-wood. The edge of the wheel is that part by which the grinding is effected; and different shapes and thicknesses are given to these edges in order to produce different results.

The workman takes the glass decanter, or other manufactured article, and holds it against the edge of the revolving wheel (Fig. 12), by

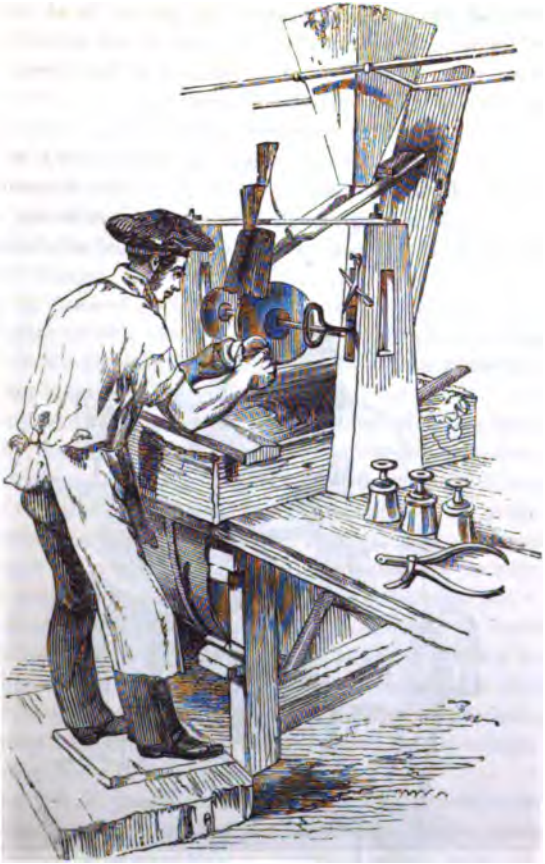


Fig. 12.

which the substance of the glass is ground down, and flat or curved surfaces produced. The vessel is held in various positions, according to the pattern required, accuracy of eye and steadiness of hand being indispensable in the workman. The iron wheels, with sand and water, are used for grinding away the substance of the glass; the stone wheel, with clean water, for smoothing the scratched surfaces; and the wooden wheel, with rotten-stone and putty-powder, for polishing.

In a separate room the stoppers or stopples for bottles are ground, and the necks of small bottles made truly circular by attaching them to a kind of lathe, and applying small tools to the surface while revolving. The value of well-stoppled bottles to the chemist renders this operation one of nicety and importance.

In addition to the cut surfaces of glass vessels, whereby such a lustrous play of colours is produced, the more costly articles are engraved, that is, devices are cut on the surface more delicate than can be produced by the cutting-wheel. A separate apartment is devoted to the operations of the glass-engraver, who is seated at a bench before a small lathe; and to this lathe he attaches one of a series of little metallic disks or wheels, generally made of copper, and varying from an eighth of an inch to two inches in diameter. The edge of the rotating disk he touches with a little emery moistened in oil, and then holds the glass vessel against the edge of the disk, by which very minute scratches or indentations are produced. By dexterous changes in the position of the glass, and in the form and size of the disks

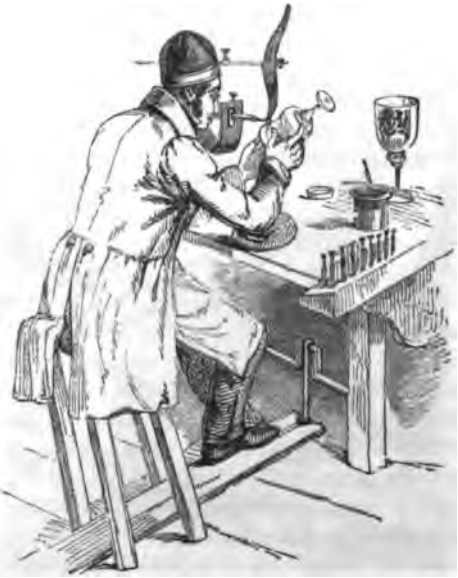


Fig. 13.

employed, he combines these indentations so as to produce beautiful intaglios or sunken pictures.

This is strictly a branch of the Fine Arts, and as such places the engraver on a different level from the other workmen. Taste, both natural and cultivated, a knowledge of the external forms of natural objects, and a delicacy of eye and hand, are all required in this operation; and we viewed with pleasure the labours of an intelligent workman engaged therein. A laudable attempt is now being made in England to diffuse among workmen a more extensive knowledge of the Arts of Design than has yet been possessed by them; and such operations as those of glass-cutting and engraving afford an ample field for the display of this kind of knowledge. We believe that the proprietor of this establishment is himself one of the council in the new Government School of Design.

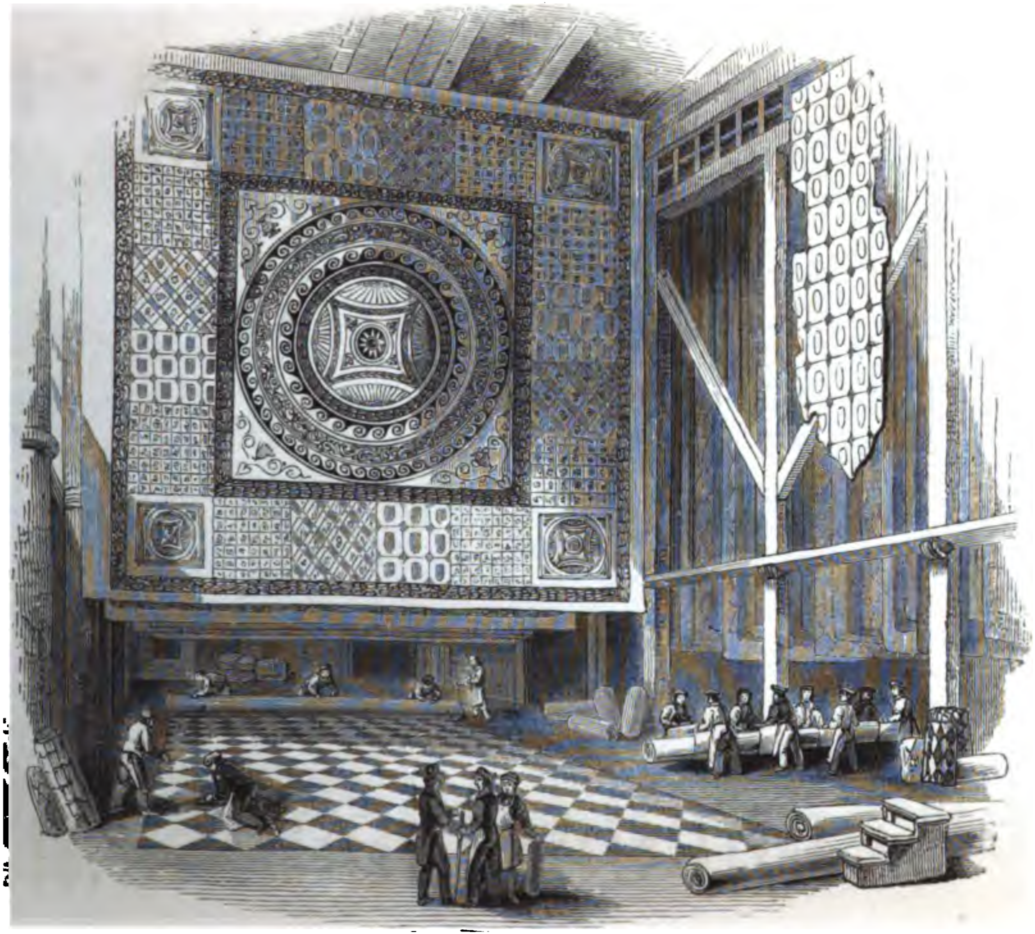
The most profitable and important articles of flint-glass are such as are largely employed and have a current sale; but the costly and delicate articles occasionally produced call for great skill and inventive ingenuity. There is a kind of cut-glass in which the projecting parts of the pattern are coloured and the sunken parts colourless. These are produced in a remarkable way; for after the working-tube has collected nearly sufficient colourless glass from one pot, the mass is dipped into another containing glass which is coloured by the addition of certain metallic oxides, by which an external coating of coloured glass is given to the mass. When the blowing and modelling are completed, this exterior coating is, in the finishing process of cutting, ground away in some parts and left remaining in others, thus producing a singularly delicate effect.

Another kind of ornamental manufacture is the 'crystallo-ceramie,' or glass incrustation, patented by Mr. Pellatt some years ago, and consisting of an opaque substance imbedded in a mass of colourless glass. A medallion or bas-relief, representing any device whatever, is moulded in a peculiar kind of clay capable of resisting the heat of melted glass; and the medallion is enclosed between two pieces of soft glass, or else is introduced into a cavity in the glass, from whence the air is afterwards extracted. The introduction of the medallion into the glass is the main difficulty in this process, and requires much skill and ingenuity, in order that no air-bubbles may exist between the two substances. When finished, and the external surface of the glass cut to the required form, the appearance of the imbedded medallion is singularly chaste and elegant; for the white clay, seen within the clear and highly refractive glass, presents an appearance nearly resembling that of unburnished silver. This branch of art, that is, the incrustation of clay devices, was invented by a Bohemian about sixty years ago; at a later period some French manufacturers incrusted medallions of Napoleon in this way, and sold them at an enormous price; but since the introduction of the art into England, under an improved form, a wide extension has been given to its applicability. Decanters, goblets, wine-glasses, lamps, girandoles, chimney-ornaments, plates, door-handles, and other articles formed of flint-glass, have been ornamented in this way; the incrustations being arms, ciphers, crests, inscriptions, portraits, small busts, caryatides, or indeed any small objects capable of being modelled or moulded in clay. The incrustation may be painted with metallic colours, which will remain uninjured by the heat required in the process.

There is a mode of incrusting opaque ornaments or devices on the surface, instead of within the substance, of the glass. This is effected by adjusting the ornament in a brass mould, and blowing and moulding the glass to it; the details requiring considerable skill, but the principle being nearly the same as in the other process.

The astronomer and the optician obtain from the flint-glass manufacturer the materials from which their lenses are made. It has been ascertained that there is a certain state of the fused glass which is best calculated for optical purposes; and when the mass has attained this state, about seven pounds weight is taken up in a conical ladle and blown into the form of a hollow cylinder. This cylinder is cut open, and flattened into a sheet twenty inches long by fourteen wide, and from two to three eighths of an inch in thickness. In this form it passes into the hands of the optician, who cuts and grinds it to the shapes required for optical purposes. The masses of glass for large telescope lenses require a somewhat different process, and extraordinary care in the choice, preparation, mixing, and melting of the ingredients: indeed, the production of good glass for this purpose is one of the most uncertain things in the whole glass-manufacture.

We terminate our visit by a glance at the elegant show-rooms or galleries, in which the finished materials, of all the various kinds above alluded to, constitute a brilliant display.



XIII.—Drying-Room. Messrs. Smith and Baber's Factory.—Face p. 281.

XIII.—A DAY AT A FLOOR-CLOTH FACTORY.

WHAT would our ancestors have thought if they could have seen the varied and glittering devices which now deck the floors of our apartments? In the times when tapestried hangings decorated the walls, the floors were either left bare or were covered with green rushes renewed from time to time as occasion required. Our old annalists and county topographers make repeated allusions to the preparations of the 'Great Hall'—a component part of most old mansions—on the occurrence of festivities, by the spreading of clean new rushes on the floor. At what period this custom was discontinued it would perhaps be difficult to say. The great beauty of the joinery-work in the floors of the majority of old mansions seems to point to the fact that they were intended to be left bare; and the polished boards, frequently arranged in a skilfully-contrived mosaic pattern, still remain to attest the care taken in their preservation. The first woven fabric used as a floor-covering in England was probably some coarse kind of drugget, for it seems at least consistent to suppose that the costly carpets imported from Turkey were not introduced till rough attempts had been made to produce a home-manufactured fabric. But be this as it may, the general use of carpets in England extended itself very slowly. It is stated in the 'Penny Cyclopædia,' that "The consumption of carpets in Great Britain up to about the middle of the last century was so very trifling, that as a manufacture, it was hardly deserving of notice; and although now so essential to our warmth and comfort, a few generations since carpets were only partially used in the mansions of the rich. Only a few manufactories, of which that at Wilton was the most important, existed in different parts of the kingdom; and at Kidderminster, which is now the principal seat of the trade, and where at least five thousand persons are employed in its different branches, the carpet manufacture did not commence before the early part of the eighteenth century. We doubt whether at the commencement of the nineteenth century one-fourth of the present number of carpets was manufactured."

Still more recent was the introduction of that kind of floor-covering which is made of *painted canvas*, and which is generally termed *oil-cloth* or *floor-cloth*,—though *painted cloth* would perhaps be a better name. The steps whereby we may suppose this material to have been gradually brought to the state usually presented by it at the present day are simple and obvious. In the first place a coarse hempen or flaxen fabric was woven and laid down as a floor-covering. It was then probably suggested that the durability of the material would be greatly increased by laying on a coating of paint, or by saturating the fibres of the cloth with oil or paint, allowed to become thoroughly dried and hardened before the cloth was brought into use. The painter would then exercise his taste in producing a *pattern* on the cloth, by using paint of different colours, and applying his brush with reference to some particular device. Then would ensue the use of *stencil-plates*, as a means of producing an unlimited number of copies of the same pattern, so as to expedite and facilitate the painting of the device. The stencil-plates were probably made of thin sheet-metal with the pattern cut or stamped out of them; a pattern could be produced by painting the canvas—previously prepared with the ground-colour all over—in the parts left bare by the stencil-plates; the pattern, too, would be more or less elaborate according as there were or were not different colours, one stencil-plate devoted to each colour. Lastly ensued that improvement which arises from printing the device by blocks, the faces of which are cut similar to the blocks in wood-engraving; a method which admits of very much closer accuracy and neatness than can be attained by the use of stencil-plates.

That these successive stages in the progress of the manufacture are not wholly conjectural may be shown by a kind of historical memento of the manufacture, still in existence. We have lately seen the first block ever cut for printing floor-cloth: it is still in the hands of the family of the manufacturer who cut it and printed from it, and remains to show the time—about ninety years—which has elapsed since the use of such blocks originally commenced. Before that time the floor-cloth manufactured, very limited in extent, as may be well supposed, received whatever pattern was intended for it by the use of stencil-plates.

Simple as may appear at first thought to be the mere painting of a piece of cloth, the manufacture of floor-cloth involves many curious processes, which are not undeserving of attention, and which have given rise to many large establishments in London.

The Floor-cloth factory of Messrs. Smith and Baber, the one to which our visit has been directed, is situated at Knightsbridge, opposite the Horse-Guards Barracks. Many of our readers, in walking across Hyde Park from the end of Oxford-street to Knightsbridge, and just before reaching the eastern end of the Serpentine, may have probably seen a high square building standing up prominently in the background, much more lofty than any surrounding building, and occasionally coming into sight between the trees. This is the factory in question, or rather it is a kind of square tower surmounting the factory; and on approaching nearer to it we see that the building itself is one of considerable extent. All floor-cloth factories are required to be both lofty and extensive in area; because, as we shall see farther on, very large pieces of canvas have to be extended at different times both vertically and horizontally.

The northern extremity of the building presents to view a rotunda, or circular apartment, forming the principal entrance to the factory. From thence the various parts of the building extend to a distance of about two hundred and fifty feet towards the south, presenting an eastern façade more decorative than is often seen in factories of the kind. On proceeding within the entrance rotunda, we come to a kind of show-room, lined on either side with specimens of the finished manufacture, mostly in the form of rolls. At the southern end of this room are two offices or counting-houses, with an entrance between them to the largest room in the factory, the one indeed which entails a necessity for considerable area and elevation. This is the 'drying-room,' represented in Fig. 1: it is about one hundred and twenty feet in length, by sixty or seventy in width, and of considerable height. The first thing which meets the eye on entering this room is a magnificent specimen of floor-cloth, remarkable alike for its large dimensions and intricate mosaic pattern: it is suspended from a considerable height, and hangs down to within six or eight feet of the floor. A still larger specimen has been recently produced at this factory for Mehemet Ali, the Pasha of Egypt; but we believe the one here deposited is deemed one of the most difficult and elaborate patterns ever produced in floor-cloth. Behind this large specimen, and along the entire western half of the room, are suspended finished floor-cloths, which are hung here to dry gradually after the painting has been finally effected: these are placed over poles near the roof of the building, and descend to within a few feet of the ground. The floor of the room is occupied by chalk-marks delineating the size or pattern of required pieces of cloth; or by men cutting a large finished piece of cloth to the required size; or by others opening a bale of canvas, and spreading it out on the floor preparatory to placing it on a roller; or by others hauling up a roll of canvas to the painting-room—one or more of these operations being carried on at a time, according to circumstances.

At the southern end of the drying-room a few descending steps lead us to the 'colour-room,' wherein all the colours used for painting the cloth are prepared. In the centre of this room is a large horizontal cog-wheel, moved by horse-power; and around it are various machines set in motion by cog-wheels acting on the larger wheel, and employed in the grinding and preparation of the colours.

Behind the 'colour-room' is an open court or yard, in which are three large linseed-oil cisterns, capable collectively of holding forty tuns of oil. From these proceed the requisite pipes for causing the flow of the oil into the proper vessels in the colour-room. In the rear of the premises, and occupying the southern side of the yard, are a carpenter's shop and a smith's shop, for the manufacture of the printing-blocks, and the repair and adjustment of various parts of the working apparatus.

Returning again to the large drying-room, and ascending a few steps, we come to a range of store-rooms over the colour-room. One of these is the canvas-room, where the canvas, brought from Scotland in bales, and afterwards rolled up into coils, is deposited till required for use: these coils, about five or six feet high, are ranged vertically on all sides of the room. Another is the 'print-room,' or store-room, where are kept the greater part of the carved blocks used in producing the patterns on floor-cloth: these, as will be easily conceived when we come to describe the process, are necessarily very numerous; in fact they amount to some thousands, and all are preserved with great care, since the fracture of any of the small projecting points would at once spoil the pattern. The room in which they are kept maintains a pretty constant temperature throughout the year; and the wood of which the blocks are formed thus avoids the injury which might result from change of temperature and moisture. In this range, too, is a colour store-room, and others which require no particular notice.

A farther ascent of a few stairs brings us to the 'frame-room,' a part of the premises so closely filled, that it is difficult at first for a stranger to see what is going forward. He soon observes, however, that the room, which is long, wide, and high, is occupied by a series of vertical frames, with canvas stretched over them, and a sufficient interval between them to allow a man to pass. Let the reader conceive a stretched canvas, about sixty feet long and twenty-four high, enclosed in a frame similar to a schoolboy's slate; and twenty or thirty of these lying parallel, with a slender scaffolding built up in each of the intervals between them; he will then have an idea of the appearance of the 'frame-room.' The greater part of these frames are about the size here mentioned; but there are others extending as much as ninety-eight feet in length, although the height is somewhat less than that of the shorter frames. Nearly on a level with this room is a floor or platform by which access is gained to the long pieces of passage floor-cloth, suspended, like the others, from near the roof of the building.

The next stage or story of the factory is the 'printing-room,' where the floor-cloth receives the pattern by which it is distinguished. Here we see square cushions—something like the inking-cushions used in hand-printing—covered with bright colours, and men transferring the colours therefrom by means of blocks to the painted canvas, the latter being stretched out on a long flat bench. Another room above this is similarly occupied by men 'printing' the narrow floor-cloths for passages.

On the summit of the building, at a considerable elevation, is a small square room, provided with windows on all four sides. From this an extensive view may be obtained in every direction, since the position of the observer is considerably higher than any other building in the neighbourhood, except church-towers. As this room is, however, rather an apartment than a portion of the factory, we shall not farther allude to it.

The tour of inspection we have just taken will have probably informed the reader that the routine of processes carried on in the manufacture is somewhat as follows:—opening the bales of canvas, coiling the canvas on rollers, hauling the rollers up to the frame-room, stretching the canvas on the frames, painting the canvas while in this position, removing the painted canvas to the 'printing-room,' painting or printing the device on it, and finally suspending it in the drying-room till ready to be employed as floor-covering. To these successive steps, then, we shall direct our attention.

If we look at the edge of a piece of floor-cloth which has been rent or worn into holes, we shall see that its foundation is a woven fabric of a coarse but stout quality. Some of the finer and superior floor-cloths are coated so completely on both sides with paint, and brought to such an excellent surface, that they assume much more the appearance of leather than of cloth; but still it is easy to satisfy ourselves of the foundation being woven vegetable fibre. Sometimes, when an old carpet of good quality has lost its beauty of appearance without falling to pieces, it is converted into floor-cloth, by having the *back* of the carpet painted and printed so as to form the *face* of the floor-cloth. But this is an exception to a general rule, and we may confine ourselves to the notice of new canvas woven expressly for the floor-cloth manufacture.

We believe that there is one, and only one, establishment in London where the canvas is woven by the floor-cloth manufacturer. The general rule is to have the canvas woven in Scotland, by parties who either confine themselves wholly to this line of business, or at least give it a marked degree of attention. That this is a business very distinct from that of ordinary weaving may be conceived from the fact that the ordinary widths are eighteen, twenty-one, and twenty-four feet. The canvas is brought partly from Kirkaldy, but principally from Dundee, a town celebrated more than any other in Britain for the extent of its manufacture of coarse sheetings, sackings, sail-cloth, and similar woven fabrics of flax and hemp. The looms for the weaving of floor-canvas are made expressly for that purpose, since all the modern floor-cloths are made without a seam. As the weft or width of the cloth extends to six or eight yards, of course the shuttle has to be driven this distance at each successive traverse of the weft-thread. At first sight these cloths have more the appearance of hemp than of flax, but hemp is used only to a limited extent, because it is found not to receive and retain the colour so well as flax; the latter is therefore the material generally employed. The canvas has a fineness of about sixteen or eighteen threads to the inch, and a degree of stoutness which may be indicated by saying that a square yard weighs about twenty-one ounces.

The canvas, after being shipped from Dundee by steam, arrives at the London factory in the form of compact bales, about three feet in length, and between two and three in width and depth. Each bale contains canvas of one particular width, the lengths and widths being regulated thus:—one kind measures a hundred yards in length by six in width, another a hundred and eight yards in length by seven in width, and another a hundred and thirteen yards by eight. The bales usually weigh about five hundredweight each. The first operation after they are brought to the factory is to open them, and cut them to such lengths as suit the dimensions of the frames, which, as we have before stated, vary from sixty to a hundred feet in length. The canvas is rolled up and deposited in the canvas store-room till wanted.

When a piece of canvas is about to be painted, it might be supposed by one whose thoughts were then first directed to the matter, that it might be laid flat on the ground, pulled and perhaps nailed at the edges to stretch it smooth, then painted, and, when dry, painted on the other side. It will be seen, however, that a very different plan is adopted in practice. A party of men unroll the canvas, and lay it down pretty evenly on the floor of the drying-room. They then take a wooden roller, rather longer than the width of the canvas, and about five inches in diameter, and lay it down on one end of the canvas. On this roller the whole of the canvas is coiled, and in that state can be easily carried from place to place. The roller, with the canvas wound on it, is then erected on one end and hauled up into the frame-room by means of a pulley. Here an iron point or gudgeon is dropped into a hole in a moveable carriage, and the roller is moved to its place in a very simple but ingenious manner. Two or more men hold the upper end of the roller; while others, standing on the floor of the room twenty or twenty-four feet lower than the others, guide the carriage in which the lower end of the roller rests. The roller is thus brought to its proper position coincident with one end of the frame to which the canvas is to be attached. This frame, like all the others, is formed of stout oaken beams, two horizontal, to form the top and bottom, and two vertical, to form the sides or ends. The roller being about the same height as the frame, and a small portion of the canvas being unrolled, it is easy to nail the edge of the canvas to one of the upright posts, thus forming the commencement of the stretching of the canvas. The wheel-carriage on which the roller rests is then wheeled onward, the canvas unrolling as it proceeds, parallel with the frame. As it unrolls the canvas is fastened temporarily to the top beam by means of a simple but ingenious contrivance called a 'quickset'—a much more intelligible name than is often applied to working tools. This quickset is a kind of screw and nut, provided with a large hook at the top, and a small pointed hook at the bottom; the large hook catches hold of a rod lying on the top of the frame, while the small lower hook catches in the canvas: there is a nut by which the screw is carried up tightly to the upper beam of the frame, so as to keep the canvas nearly at its proper height; while the upper hook, by being able to move along the rod, suffers the quickset to move to the right or left as the canvas becomes stretched. This is only a temporary contrivance, used while the immense area of canvas is being adjusted to the four sides of the frame; but it is one of those ingenious adaptations which could only result from a steady observance of the object in view.

When the low-wheeled carriage, in which the roller rests, has travelled from end to end of the frame, and the canvas has become wholly unrolled, and the upper edge temporarily held up by a number of 'quicksets,' the roller is entirely removed, and the second or remaining upright edge of the canvas is nailed to the other upright beam of the frame. It will readily be understood that, if this beam were a fixture, it would be next to impossible to nail the canvas to it with sufficient tightness and stretch it in every part. The beam is loose, and the edge of the canvas is nailed to it while the canvas itself is very loose. Two screws are then brought into use, one attached to the upper end and the other to the lower end of the beam; and each screw being worked, the post is drawn forward until the canvas is fully stretched; after which the beam is fixed, and the canvas remains stretched. When it is considered that each of these pieces of canvas contains from fourteen to eighteen hundred square feet, and that it is drawn out nearly as tight as a drum before operations are commenced upon it, it will be readily supposed that a powerful force is required to effect the requisite strain. When the two vertical edges are properly secured, the upper and lower horizontal edges are fastened. The upper edge is nailed, at distances of between two and three inches; and the 'quicksets' are removed when their aid is no longer required. The fastening of the lower horizontal edge requires a force analogous in kind to (though not so great in amount) that applied to the vertical edge. The edge is nailed to the lower beam, and the beam is forced down by means of levers, chains, and hooks, until the canvas is stretched as tightly in the vertical as in the horizontal direction; and in this position it remains for several weeks, while the greater part of the processes are being wrought.

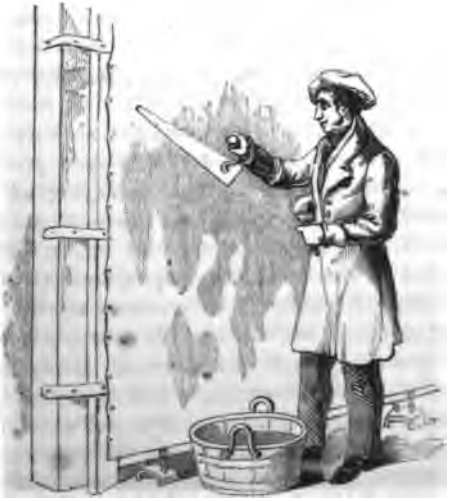
This stretching or 'framing,' then, it will be seen, is a much more important part of the operations than a first thought would lead us to suppose. The canvas is to be painted on both sides; and the mode of framing just described enables both surfaces to be brought equally into a vertical position. The distance between the frames is probably about thirty inches; and in this narrow space is built up a scaffolding so slender that one almost wonders how it can maintain stability. It is a scaffolding of four tiers in height, to enable the workmen to reach every part of a surface twenty-four feet high. It is necessarily detached from the canvas on either side, and consists in fact merely of a nine-inch board, supported at intervals of every few feet by vertical posts. Access to the upper tiers is gained either by ladders quite upright, or by ledges placed on the upright beams at the end of the scaffolding—a contrivance intended to save as much room as possible between the frames.

If we examine a piece of floor-cloth we shall see that the back is painted as well as the face, although no pattern is imprinted upon it: this is done to increase the durability, the cleanliness, and the appearance of the canvas; but the quantity of paint laid on the back is of course much less than that applied to the face of the cloth. The first operation is to level the surface of the canvas, and to prepare it for the reception of the paint. This is done to the back first, and in the following manner. A weak solution of *size* is prepared, and laid on the canvas with a brush; and while thus wet the canvas is rubbed well with a flat piece of pumice-stone, to level the slight irregularities which occur in the fibrous material. The liquid size not only facilitates this process, but by its gelatinous quality prevents the oil of the subsequently applied paint from penetrating too far into the substance. It is found that the size makes a good foundation or hold for the paint; but it is also found that if the oil penetrates through the canvas the floor-cloth will become brittle, and not sufficiently pliable; and to prevent this is one of the objects of the size-priming. The pumice-stone—a lava from Vesuvius or Etna—is cut by hatchets into brick-shaped pieces about six inches in length by two in thickness. The workmen rub to and fro with these pieces of pumice over the wet canvas, until the surface is rendered considerably smoother than in its natural state. They mount the highest stage of the scaffold, and rub down the upper portion of the canvas first: then they descend to the next stage, proceeding from end to end of the piece of canvas sixty or a hundred feet in length; and so on to the lower stages.

While the sized canvas is drying, we will visit the colour-room, and briefly notice the nature of the paint applied to the canvas. The painting of floor-cloth is, in principle, analogous to house-painting, though different in some of the practical details. The materials employed are the usual dry, earthy, and crystalline colours; such as white-lead, the ochres, the chromes, verditer, Prussian blue, vermilion, &c. These are mostly brought to the factory in tubs or small casks, and are prepared for use in the colour-room. The large earthy colours are ground to powder by means of a crushing-roller four feet in diameter by about twelve inches thick: this is worked by a horse; and as the shaft belonging to the roller has at the top a large horizontal cog-wheel by which other machines are worked, the whole, or any part of them, are set in operation at one time. When the pigment has been brought to the proper state of fineness by this or any other means, it is put into a tall open vessel called a 'mixing-tub,' in which a stirrer is kept rotating by a shaft placed in connection with the large cog-wheel. Linseed-oil, flowing through pipes from the cisterns behind, is introduced into the mixing-tub; and the stirrer works the ingredients well up together until completely amalgamated. But this mixing would not be sufficient to bring the paint into a proper state for use, since the dry ingredient, although fine, was by no means an impalpable powder. The paint is therefore allowed to flow from the mixing-tub into a vessel beneath; and is thence laded into the hopper or orifice of a pair of mill-stones precisely analogous to those by which corn is ground. There are two mixing-vessels, and two pairs of millstones; all four machines being worked by the large cog-wheel. As the paint flows down into the shallow vacant space between the millstones, it becomes ground by the rotation of the upper stone or 'runner,' and when perfectly smooth and homogeneous, is allowed to ooze out from between the 'runner' and the 'bedstone' into a vessel beneath. The runner is loaded or not, according to the fineness of the paint to be produced. From the vessels into which the paint flows it is conveyed into store-tubs, where it is kept until wanted for use; it is then drawn off into the paint-pans or pots, from which it is used. For some of the finer kinds of colours, or where the quantity required is not such as to render the use of the millstones necessary, a flat stone and hand-muller are employed in the grinding of the paint, such as are commonly used by house-painters; but the principle is just the same.

The paint employed for floor-cloth has these two peculiarities, when compared with that used in house-painting;—it is very much stiffer or thicker, and has scarcely any turpentine in its composition. Both of these characters are given to it to ensure the durability of the cloth; since a large body of paint can be laid on when the consistency is thick, and the paint becomes harder and more durable when the liquid employed is wholly or almost wholly oil,—although a much longer time elapses before the paint becomes thoroughly dried and fit for use.

When the paint is prepared, with a thickness or consistence not much less than that of treacle, it is applied to the cloth in a very curious manner, more analogous to the manipulations of a plasterer than those of a painter. The workman holds in his left hand a stout thick brush, which he dips into the paint-pot, and then dabs or splashes on the canvas; the paint is too thick to be brushed over in the usual way, and is therefore laid on abundantly in a few detached patches. The workman holds in his right hand a kind of trowel, consisting of a long narrow blade, twelve or fifteen inches in length, decreasing in width towards one end, and having at the other a handle which bends



Trowel-painting.—Fig. 2.

back over the blade. With this trowel, as represented in Fig. 2, the workman draws the paint over the canvas, smoothing it repeatedly, and drawing a supply from the patches or masses of paint which had been thrown on by the brush. The trowel is worked with its plane or face not precisely parallel with the surface of the canvas, but somewhat inclined, so as to rub or scrape the paint into the fibres of the canvas. The scaffolding, being erected somewhat on the principle of that used by builders, has its successive stages so far distant as to allow the arm of the workman to reach over the intervals between them; so that by descending from one stage to another, and working on the portions of canvas intervening between them, the whole piece can be prepared in a similar way. The edge of the plank or platform forming each stage of the scaffolding is about a foot or fifteen inches distant from the canvas, so that the workman is enabled conveniently to reach it.

The process here described relates to the *back* of the canvas—that surface which is to be underneath or next to the floor when the finished floor-cloth is in use. After this 'trowel-colour,' however, has been laid on the back of the canvas, and when it is nearly dry, operations commence on the face, which has hitherto been left untouched. The surface is wetted with a weak solution of size, and rubbed down with flat pieces of pumice-stone, as in the former case, and with the same view of preparing the fibres of the canvas for the reception of the paint. When this is done, the face is not further proceeded with until the back is finished.

The thickness of the colour laid on, and the absence of turpentine or 'driers' in the paint, render the drying a slow process; from ten days to a fortnight being required for the drying of the 'trowel-colour.' When this is, however, effected, a second coating of paint is laid on, having the same colour as the former, but differing from it in two respects: it is much more liquid, on account of the addition of an extra portion of oil, although considerably thicker than common house-paint; and it is laid on wholly with a brush, instead of being worked conjointly with a brush and a trowel. Hence it is called the 'brush-colour,' to distinguish it from the first or 'trowel-colour.' The tint is of no particular importance; but we believe that each manufacturing firm is accustomed to adopt one particular colour for the back of their floor-cloth, which thus becomes a kind of symbol; besides which, certain private marks are stamped on the back of the cloth; after which that surface is finished. The time has been when a duty was laid on floor-cloth, and when the Excise officer exercised that supervision which is so vexatious and mischievous in manufactures; but this is no longer the case.

The back of the canvas is entirely finished before the face has undergone any process except the sizing and rubbing down with pumice-stone; but now the preparation of this surface is attended to. A 'trowel-colour,' similar in consistence to that used on the back, is applied, and allowed to remain untouched till dry. Then the face is pumiced a second time, to work down some of the asperities and projections which still remain on the surface. To this succeeds a second trowel-colour, in every respect resembling the first; and after a due interval for drying, the surface is a third time rubbed down with pumice. Again is the routine repeated, by applying a third trowel-colour, and following it up with a fourth rubbing down with pumice; after which is given a 'brush-colour.' The object of this careful and long-continued series of operations, which occupies a period of two or three months, is to bring the surface of the canvas to a state of great smoothness and pliability. The repeated rubbing with pumice-stone not only levels irregularities, but imparts to the canvas much of the pliability and durability of leather. We believe that where floor-cloths are made expressly to be sold at a low price, the routine of processes is more expeditious and less complete than that here indicated; but as a means of giving a better insight into the matter, we describe the operations of an establishment where none but the better kinds are manufactured.

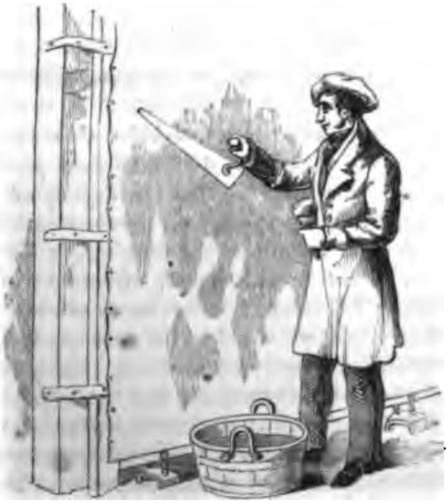
We now approach that class of operations which, so far as appearance is concerned, is the most important of any, and the most interesting to a stranger who visits a factory of this kind: we mean the *printing*, or transfer of a device to the surface of the cloth. It must be borne in mind that the canvas is all this time in a vertical position, stretched over the frame to which it had been fixed two or three months before; and that the colour of the final coating of paint is that which is to form the ground or foundation colour of the pattern. The printing is effected while the canvas is lying horizontally on a long bench or table; and an entire removal is therefore necessary. The painted canvas is gradually loosened from the nails by which it is fastened to the frame, and is transferred to a roller whose length nearly corresponds with the width of the canvas. The canvas in its original state weighs not much less than two hundred pounds; and the vast body of paint subsequently applied to it increases the weight very considerably; so that the loosening of the canvas from the frame, the transference to a roller, and the hauling up of the roller with its load to the printing-room upstairs, are arrangements requiring some tact and judgment. When the roller is carried up, it is placed horizontally at a few inches from the floor, in front of a very long work-bench; and two gudgeons or projecting axles at the ends of the roller being placed in sockets, the canvas can be uncovered from the roller by the rotation of the latter, and spread out upon the bench to be printed.

Here it will be desirable to offer a few brief explanations respecting the patterns of floor-cloths and the modes of producing them. We have before alluded to the original block first cut for the floor-cloth manufacture. This is now in the possession of the firm whose establishment we are describing—an establishment which was the earliest in England in this line of business. Before the year 1754 Mr. Nathan Smith, the founder of the firm of Messrs. Smith and Baber, was accustomed to manufacture floor-cloth in pieces of two or three yards square, in the only method known at that time. Holes were cut in some determinate pattern in thin plates of metal or pasteboard; and these plates being laid on the canvas, and paint applied with a brush, the paint could only reach the canvas at those parts which were not covered by the plate: this is the method of 'stencil-painting,' which is occasionally applied to painting the walls of rooms in distemper, and for other purposes. Each small square of floor-cloth had a border given to it all round; and if a large room were to be covered, several such pieces had to be used. To what extent the floor-cloth manufacture was carried on at that time we have no means of knowing; but it must have been very limited indeed.

A necessary result of stencil-painting is, that very little *substance* of paint is laid on the canvas, since the application of a brush levels the paint to a mere film; and Mr. Smith sought for some means of obviating the defect. He conceived that if a thick wooden block were prepared, the surface levelled and smoothed, a pattern sketched upon it, and this pattern cut out by means of carving tools, the device might be transferred by a process analogous to that of printing. Most readers are at the present day aware that the blocks used for woodcuts, such as those which illustrate the present work, are cut so as to leave the pattern untouched; that is, the parts of the block cut are hand-muller are employed in the grinding of the paint, such as are commonly used by house-painters; but the principle is just the same.

The paint employed for floor-cloth has these two peculiarities, when compared with that used in house-painting;—it is very much stiffer or thicker, and has scarcely any turpentine in its composition. Both of these characters are given to it to ensure the durability of the cloth; since a large body of paint can be laid on when the consistency is thick, and the paint becomes harder and more durable when the liquid employed is wholly or almost wholly oil,—although a much longer time elapses before the paint becomes thoroughly dried and fit for use.

When the paint is prepared, with a thickness or consistence not much less than that of treacle, it is applied to the cloth in a very curious manner, more analogous to the manipulations of a plasterer than those of a painter. The workman holds in his left hand a stout thick brush, which he dips into the paint-pot, and then dabs or splashes on the canvas; the paint is too thick to be brushed over in the usual way, and is therefore laid on abundantly in a few detached patches. The workman holds in his right hand a kind of trowel, consisting of a long narrow blade, twelve or fifteen inches in length, decreasing in width towards one end, and having at the other a handle which bends

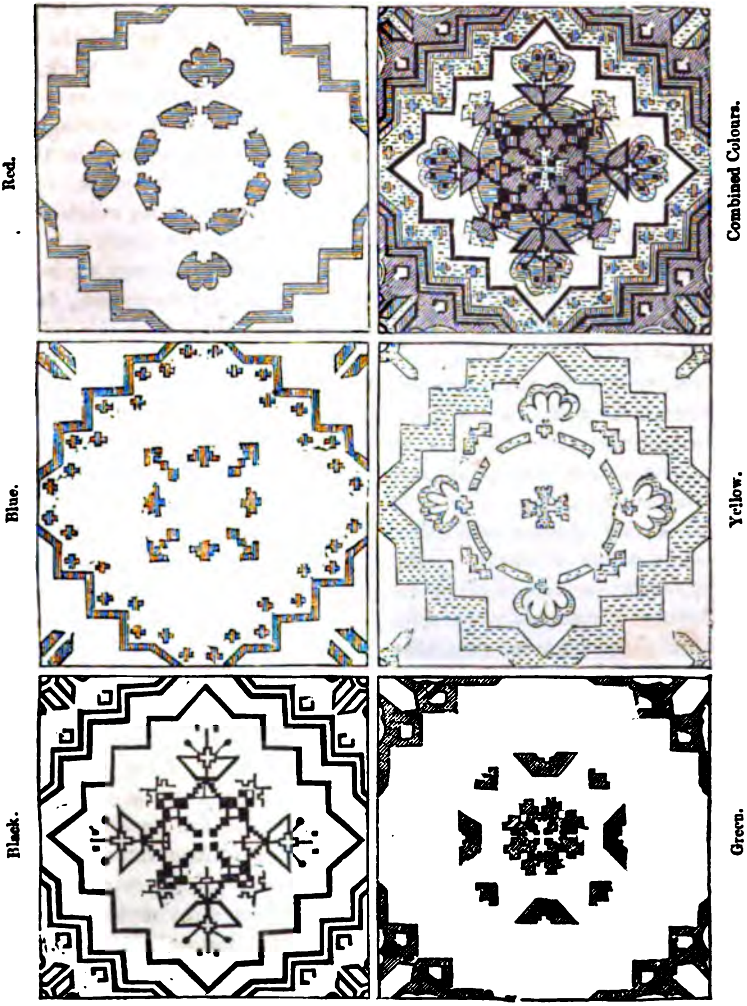


Trowel-painting.—Fig. 2.

Mr. Smith, like inventors generally, was very careful of his production, and for a considerable period printed all his floor-cloths with his own hand, allowing none of the workmen to see the block, and adopting singular precautions to damp the curiosity of visitors. The original manufactory occupied the site of the present building, and remained standing for forty years, when it was burnt down in 1795. The present structure has been standing not quite twenty years.

The method of printing, originally planned, was very much more simple than that now adopted, owing to a circumstance which it is important that we should clearly explain. If, instead of printing in *one* colour, we adopt *several*, the complexity is greatly increased; for it would be impossible to paint one part of the block with one colour, and one with another, and then transfer the device to the canvas. It is necessary to have as many blocks as there are colours; and the great difficulty consists in adjusting these blocks so as to unite in producing one pattern. The principle is analogous to that of 'colour-printing,' introduced within a few years, wherein, instead of printing with black or blue or any other monochromatic ink, we have several colours combining to produce one pattern. In such a case a series of plates is prepared, either by cutting away those parts which are not to form the pattern, or inserting slips of copper to form the pattern; each plate being made to furnish one particular portion of the device, viz., that of one particular colour. So it is with floor-cloth printing, under a different modification to suit the object in view.

A moment's consideration will show that the carving of the blocks must be a point of great nicety; for if a portion of the device, cut on one block, occurs at the same point as a portion on another block, the two colours will be confounded together, and the device lost. All the blocks are precisely the same size (about fifteen inches square), all are rectangular, and all are applied successively to every part of the floor-cloth, in patches corresponding with the size of the blocks. Each block is cut away at those parts which are left prominent in all the other blocks; so that it will not impart colour to the cloth where the latter would be coloured by any of the remaining blocks. Perhaps we cannot better illustrate this than by taking an actual specimen of floor-cloth, printed in five colours, and showing the precise device cut upon each of the five blocks, as far as we can do so on a small scale. In this group of patterns the colours are represented heraldi-



Blocks to produce one Pattern.—Fig. 4.

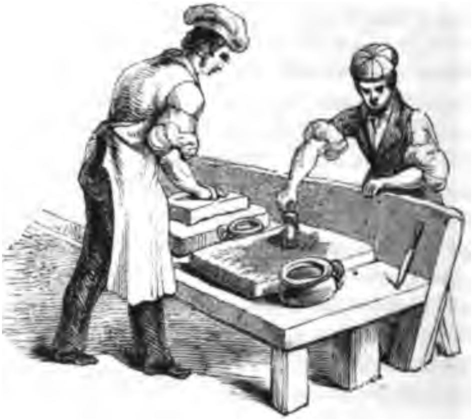
cally, the only way of so doing when black ink only is used; by heraldically we mean the adoption of certain modes of engraving used in printed plates relating to heraldry, such as the following:—

white is represented by a white space, black by a black space, yellow by dots, green by oblique parallel lines, red by vertical lines, blue by horizontal lines, &c. One of the six figures represents the finished pattern, built up as it were of five separate portions; and the others show how the blocks are separately fitted to join in producing the design. Of these five, one is yellow, and the dotted portion shows the parts which are left prominent in the block, all the rest being cut away. In another we see, by the arrangement of oblique lines, the pattern intended to be given in a green colour. The red and the blue are in like manner represented by their peculiar lines; and the black portion of the pattern is given in the form which engravers call 'solid.' It will be seen that the device differs greatly in the several blocks; so much so that they could hardly be recognised as uniting to form one pattern, unless that pattern were presented at the same time. In some rare cases as many as ten or twelve colours have been used in one floor-cloth; and this entails—not only the cutting of an equal number of blocks—but a greatly increased amount of care in every part of the operations.

The choice of patterns for floor-cloth is of course, like that of calico-printing, a matter of taste. Each manufacturer exercises his ingenuity, or avails himself of the ingenuity of others, in devising new patterns. Sometimes, when a piece of ancient tessellated pavement is discovered, such as has recently occurred in the City, the mosaic pattern is immediately copied, and introduced, either as a whole or in part, as a pattern for floor-cloth. But from whatever source the pattern is derived, the mode of transferring it to the several blocks is nearly as follows. The pattern is first drawn and painted in a complete and careful manner, on a sheet of stiff paper exactly the size of the blocks, every colour and every portion of the device being given precisely as it is to appear in the finished floor-cloth. Another piece of paper is then taken, and laid under the first, and by means of a pin or pricker one portion of the device is transferred in outline to the lower paper. Thus: suppose we commence with green; the workman follows the outline of the green portion of the device, pricking through both papers with a pin, and thus having a series of pin-holes very close together. The under paper is removed, and another one placed in its stead, which we will suppose is to receive the red portion of the device. The workman transfers the outline of this red portion, by means of pin-holes penetrating through both papers to the lower one; and this is in its turn removed to make way for a third. Thus the operation continues, until as many pricked papers are prepared as there are colours; and it must be obvious from the nature of the method that these outlines are transferred precisely in the way in which they occur in the model pattern. This pattern thus becomes almost one mass of perforation, but it has answered the purpose for which it was intended.

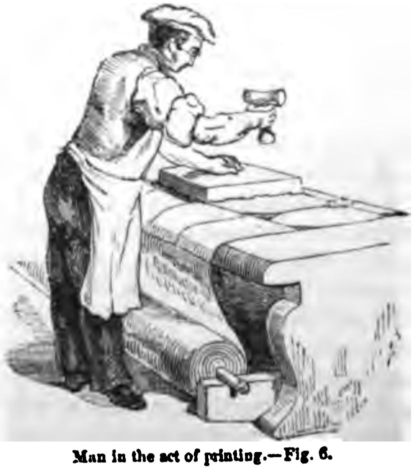
The blocks on which these devices are next to be transferred are made with especial reference to the avoidance of warping or twisting. They are formed of two thicknesses of white deal and one of pear-tree wood, ranged so that the grain of the one shall cross that of the adjoining one, and thus counteract any tendency to distortion. The several layers, after being glued, are kept for some time in a powerful screw-press, as a means of ensuring as close a joint as possible; and when the whole mass, about two inches and a half in thickness, is dried and planed smooth, the pear-tree surface is ready to receive the device. The pricked paper is laid upon the surface, and a little pounce or pounded charcoal, held in a bag which is dabbed on the paper, penetrates the pin-holes, and leaves a series of slight marks on the block sufficiently distinct to guide the pencil of the carver in working out the pattern. He then proceeds to cut away all the parts which do not form the device, carefully leaving the latter. Occasionally, if the pattern admits of it, small brass pins are inserted to make up the form, and brass pins are also fixed at the corners to guide the printer in joining the several portions which he prints, and in making the coloured portions to fall in their proper places.

When the cutting of the set of blocks for one pattern is completed, the blocks are soaked with oil on their upper surface, to fit them better for the purpose they are to fulfil; and when all is ready, the printing-process commences. The printing-room contains a great number of flat cushions similar to those represented in Fig. 5. Each cushion measures about three feet by two and a half, and consists of a pad of flannel covered with a piece of floor-cloth. There are, for every pattern, as many of these cushions required as there are colours in the pattern about to be printed. A pot of paint, not so thick as that before spoken of, but still having a considerable degree of consistence, is placed beside each cushion, and a man with a brush lays a plentiful coating of paint on each; or at least there are one or more boys and men so engaged as to keep all the cushions supplied with sufficient rapidity



Cushions.—Fig. 5.

The printer then takes one of the blocks, which he holds by a kind of leathern loop passing over the hand, and dabs it down on the wet cushion, whereby a tolerably thick layer of paint is caught up by all the projecting parts of the block. He proceeds to the long bench on which a portion of the prepared canvas is spread out, and stamps the block down upon the cloth, whereby the first germ of the pattern' is imparted. He holds in his right hand a very heavy hammer, with which he forces the block down into close contact with the cloth, as a



Man in the act of printing.—Fig. 6.

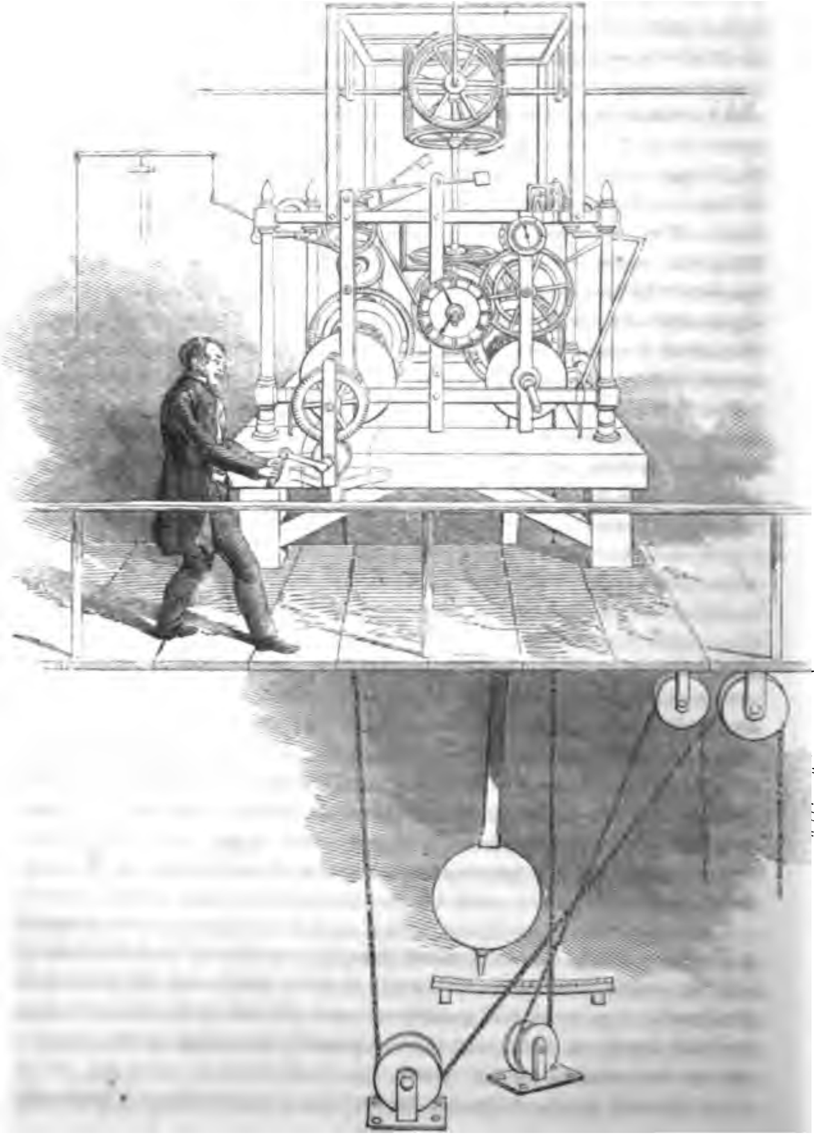
means of ensuring the transfer of the paint. A second impression is then effected with the same block close to the first, care being taken that the two impressions shall form one continuous pattern. The printing thus proceeds until the whole width of the piece corresponding with the length of the bench is printed, as far as one width of this block can do it. Then ensues the application of the second block, used with paint of a different colour; the block being pressed successively over every part of the cloth, as the first had been. In this second printing a twofold accuracy is required: first in respect to the successive applications of the same block across the width of the cloth; and next in reference to the junction of the colour in the proper relation to the colour of the preceding block; both of which are attained by attention to the guide-points fixed in the corners of every block.

When the whole of the blocks have been used in succession, and the entire printing effected across the cloth, and to a length of fifteen inches, the roller on which the cloth is wound is turned a little, by which the printed portion is allowed to fall down behind the bench, and a new portion to occupy the horizontal surface of the bench, after which the printing proceeds as before.—There is a long aperture in the floor of the printing-room, through which the cloth is allowed to descend as it is printed, and to hang down freely exposed to the air; new portions being unrolled from time to time, as the printing advances, and the finished portions fall lower and lower.

A slight examination of a piece of floor-cloth will show that there is nowhere a large smooth patch of paint, except in large plain patterns; but that the paint is laid on in little nodules or spots, technically called 'teeth,' from an eighth to a quarter of an inch square. The object of this plan is the following:—If a flat surface of wood, say two or three inches over, were dabbed down on a cushion covered with thick paint, the paint would be taken up very unequally, on account of a kind of adhesion between it and the block and cushion: it would be accumulated more plentifully near the centre than near the edges, and would look patchy and unequal when thus laid on the cloth. Instead of this plan, therefore, the surface of the wood is broken up into a number of smaller surfaces by means of little channels which act as air-holes, and which enable the paint to be taken up equably. We see that each of these little spots or 'teeth' has the paint very thick in its centre; this contributes to the durability of the cloth: but if a similar thing were to occur with a surface an inch or two square, the effect would be very unsightly.

In printing passage floor-cloths of narrow but determinate breadths, the canvas is cut into strips after being prepared on the frames, and is then printed in the same manner as the other, with the exception that the border is printed by narrow blocks much smaller than the square ones. All the floor-cloths of either kind are allowed to hang suspended in the air in the drying-room until fit for use; when they are lowered, spread out on the floor, and cut or planned according to the purpose to which they are to be applied.

In concluding our brief notice of this interesting branch of manufacture, we may remark that floor-cloth is capable of being prepared in such a way as to form a very durable material for covering the roofs of houses. We have seen some which has been so employed for nearly twenty years, and is still in good condition.



XIV.—Clock of St. Ann's Church, Limehouse.—Face p. 305.

XIV.—A DAY AT A CHURCH-CLOCK FACTORY AND A BELL-FOUNDRY.

HAS the reader ever visited the belfry or the clock-room of a church tower? An hour may be spent in such a spot, if not merrily, at least pleasantly and profitably. There is food in such a place for different phases of contemplation. We are elevated far above the busy hum of street traffic, and can forget for a brief space the world and its multitudes. We are in a room devoted to old Father Time, whose movements are measured by the work of men's hands, and whose hourly progress is recorded in tones which ring loudly through the church tower—progress which, however, Young doubts our power to value at its proper price:—

> "On all-important Time, through every age,
> Tho' much and warm the wise have urged, the man
> Is yet unborn who duly weighs an hour."

We have beneath us a silent building whose purpose is of a solemn and sacred nature, and the invitation to which is sounded on the bells in the room where we are standing. The mournful tones which announce the consignment of a lifeless body to the grave, and the merry peal which lends its aid in times of rejoicing, alike emanate from the belfry. We may then turn our attention to the mechanism by which these effects are produced; and in proportion to our comprehension of the details, so will be our admiration of the skill displayed in the combined results.

Having recently paid such a visit as is here alluded to, we make it a theme for one of the present series of papers. The philosophy of church clocks and bells is a large subject; but it may be possible to give such an epitome of the mode of manufacture, the mode of action, and the mode of arranging these pieces of machinery, as to convey a few general notions on the matter.

In the first place, everybody knows that a church clock is generally fixed in the tower, or in some elevated part of the building; and it is also known that many churches exhibit clock-faces or dials in four different directions, so that the hour of the day may be observed by persons on all sides of the church. Now, we doubt not that many who may read this paper have entertained the opinion that in such a case there are four clocks, one for each dial or face, and who cannot conceive how all the four hour-hands and the four minute-hands can be moved by one clock. There are also, it is probable, many different opinions as to whether the bell or bells which strike the hour, which chime the quarters, which (in some churches) play a psalm or hymn-tune at certain intervals, which are tolled at a funeral, and which are rung at times of rejoicing, are all, or any, struck by the clock itself, or whether by men who act as bell-ringers. It may therefore be as well to state at once, that when a church tower exhibits four clock-faces, all at equal height, and opposite to four different points of the compass, all the hands are moved by the mechanism of one clock, which is placed in the midst of the tower at equal distance from all the four faces. With respect to the bells, it may be stated that they are hung either over or under the clock, according to the size and general arrangement of the church tower; and that the hour is struck on a bell by a hammer moved by the clock; the quarters by similar mechanism acting on other bells; the psalm or hymn-tunes by the action of a rotating barrel similar to those seen in musical snuff-boxes; and the tolling and pealing by bell-ringers, who pull ropes connected with the bells.

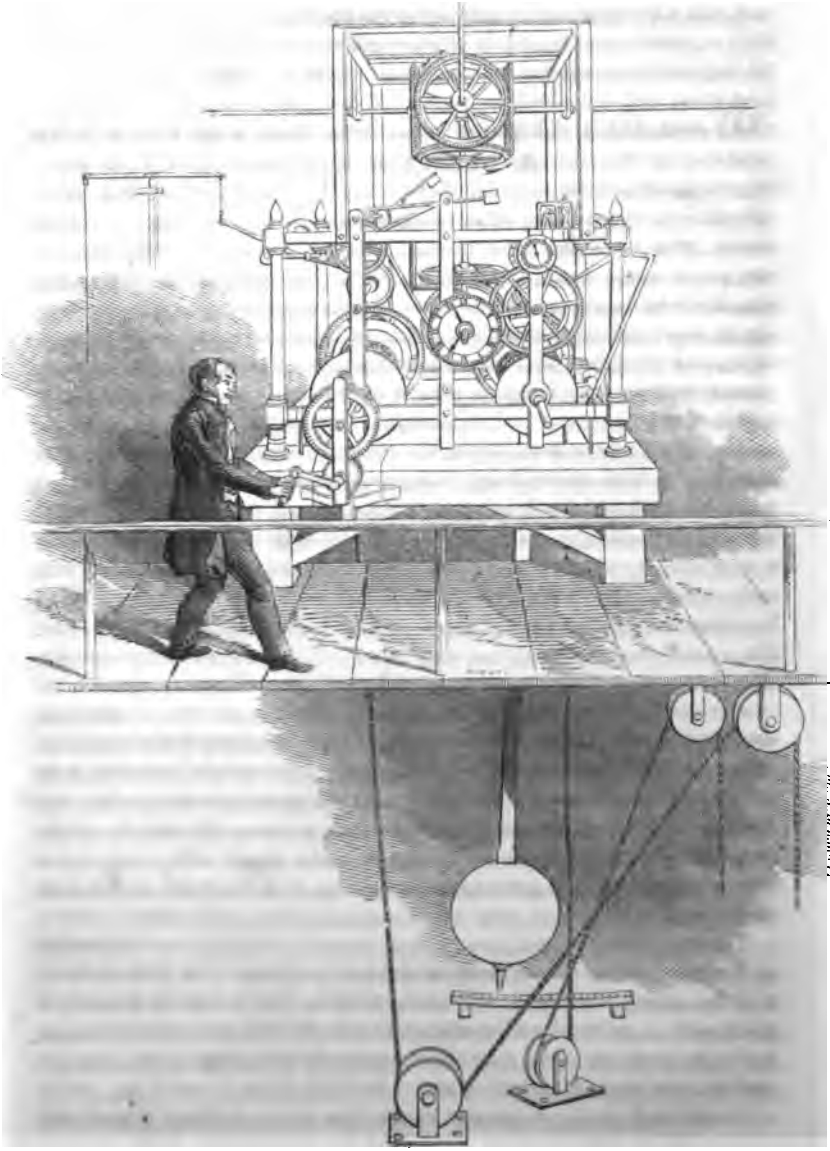
There is in the eastern part of London a church clock which stands at a greater height from the ground than any other clock in or near the metropolis—not even excepting that noted city monitor St. Paul's clock, and which presents four very large faces on the four sides of the tower. This clock, which is that of St. Ann's church, Limehouse, is the one alluded to in a former paragraph; and we, perhaps, cannot do better than make it the text for what we have to offer on this subject.

The value of room in a church tower is such that the approach to the bell-loft and clock-room is generally narrow and awkward to a degree which renders the ascent anything but inviting. The short, narrow, steep, dark, and winding stairs; the loopholes through which a cutting blast of wind finds entrance; the small doors and outlets; the dreary loneliness, and no less dreary echo of the footsteps; the cold and the dust—all are familiar to those who have ascended to the upper part of St. Paul's cathedral, and are almost equally observable in other church towers, including the one to which our attention is here directed.

On ascending to a height of about a hundred and thirty feet, in the tower of Limehouse church, we find ourselves in the 'clock-room.' This is a square room, bounded on the four sides by the thick walls of the tower, and having a wooden flooring on which the clock rests. The light is very limited, and it is not till the eye has become a little accustomed to the gloom that the objects in the room are discernible. The clock is seen to be enclosed in a wooden case, about eight feet high, six feet wide, and four feet deep, the two opposite sides of which may be thrown open by means of folding-doors, thus exhibiting a complicated assemblage of wheel-work and other mechanism within.

Our frontispiece is so drawn as to show the general arrangement of the clock and its mechanism. The clock contains about thirty wheels, some of which govern the motion of the hands; others the striking of the bell. There are two barrels, from which weights are suspended by a cord, and the mode of winding up these is here represented, as well as the small dials for the guidance of the man who is winding. The arrangements of the pendulum, together with other parts of the mechanism, are here seen, and will be understood better as the description proceeds.

The clock is placed in the centre of the room, and a visitor can walk entirely round it, without interfering in any way with the mechanism connected with the clock-faces visible outside the church. It may then be asked, how are the hands on these faces brought into connection with the moving machinery? We find an answer, by observing the arrangements overhead, as we pass round the clock. There is a horizontal bar of wood extending from the clock on each side to the wall opposite to it; and on this bar is placed an iron rod, which is set in rotation by the clock, and, in its turn, causes the hands to rotate round the clock-face on the outside of the tower. There are four of these rods branching out from the clock in a horizontal position towards the four points of the compass, each rod governing the movement of one pair of hands. On looking downwards from the clock-room we see the mechanism by which the clock is set going, and also that by which the bell is struck every hour. There are neither chimes nor



XIV.—Clock of St. Ann's Church, Limehouse.—Face p. 305.

Neither a pocket-watch, nor an eight-day dial, nor a common Dutch clock, will exactly convey an idea of the construction of a church-clock: for instead of being moved by a spring, as the two former, it is moved by a weight; while on the other hand its accurate finish of workmanship is wholly unrepresented in the Dutch clock. Generally speaking, the frame-work of a church-clock is made of iron, the principal wheels of brass, and some of the pinions and finer work of steel. The arrangements of the maker are therefore regulated according to the number and parts of the clock made at his factory. Whoever has seen a watchmaker at work must have observed the extreme minuteness of his tools and working apparatus: but such a person is not strictly a *maker* of watches; he only puts together and adjusts and repairs the various parts which have been made by many different hands. In the clock-manufacture, and especially in church-clocks, this subdivision of employments is not carried out to nearly so great an extent. At Messrs. Moore's factory almost every part of the mechanism of a church-clock is made within the establishment, except the rough castings in iron and brass. In the smith's shop all the forging and filing of arbors, bars, and other works of iron, are effected; as well as the case-hardening of the finished pieces. In the wheel-cutting shop is carried on the beautiful operation by which the teeth of wheels—that important department of all such manufactures as this—are cut. In other shops the general fashioning and adjustment of the numerous pieces which form a clock are effected, aided by various pieces of mechanism, such as lathes for turning brass, iron, and wood, drills, revolving machinery, polishing apparatus, &c. Those who are accustomed to factories of this kind will easily understand the appearance and general arrangement of such a place; those who are not must picture to themselves a great number of men working on pieces of metal which require great skill and care in their preparation.

Without attending particularly to the classification which a clock-maker would lay down, we will separate a church-clock and its mechanism into five parts—1st, the moving power; 2nd, the 'movement,' or going wheels; 3rd, the regulation, or pendulum arrangements; 4th, the indication, or mechanism connected with the hands; and 5th, the striking machinery; and will briefly notice their construction. Any attempt to follow the minute details of clock-making would be quite out of the question, and will not be made here.

First, then, the *power*. Every child knows that the old familiar clock, which has perhaps formed one of the household inmates as far back as he can remember, is 'wound up' occasionally, not by turning any wheel or handle, but by elevating an iron weight to the height of the clock; almost every child knows that the little pocket-watch, whose tickings excite such astonishment in his mind, is 'wound up' by means of a very small key; but there are many children of larger growth who are utterly at a loss to know what this winding-up really means. The main body of a clock or watch consists of many wheels which work one into another, insomuch that if one wheel moves, the others are drawn into motion by it. But there must be something to impart this motion in the first instance; and this is called the *power*. We know that if the pendulum of a common clock be stopped, the clock is stopped at the same moment; and that the movement of the clock is renewed when the oscillations of the pendulum are renewed. Hence many persons may suppose that the pendulum is the source of the clock's motion. Again, there are stop-watches in which, by moving a little pin, the watch may be made to stop; and then, by a contrary movement, the going of the watch may be renewed; and hence the pin seems to be the source of motion. But both these suppositions are erroneous. In both these cases of stoppage, the rotating wheelwork is checked by a small piece of mechanism, and the motion is renewed when the check is removed; but the *production* of the motion is a totally different affair. In a common pocket-watch, the key by which the winding-up is effected is placed on a small piece of mechanism called a 'fusee,' from which a chain extends to a brass box or barrel. This barrel contains a fine and highly tempered steel-spring, which becomes coiled up very tightly by the rotation of the fusee and the winding on it of the chain from the barrel. This tight coil is so different from the natural state of the spring, that the latter exerts a powerful pulling force in its endeavour to regain its original position; and this force tends to make the barrel in which it is fixed rotate, because by this means only can the original state of the spring be regained. When once the barrel is made to rotate, that rotation can be communicated, by toothed wheels, to other mechanism. Such is the source of power in pocket-watches, in chronometers, and in the dials which are now so much used in public buildings and large apartments.

In church-clocks, turret-clocks, and common house-clocks, there is no such spring as that alluded to in the last paragraph. There is a line or rope, descending perpendicularly from a particular part of the wheel-work, and having an iron weight suspended from its lower extremity. The iron appendage of course exerts a gravitating force in proportion to its weight, and descends gradually; but, from its mode of attachment, it cannot do so without causing the rotation of a barrel round which the cord is wound. When the pendulum is stopped, either purposely or accidentally, a catch or detent falls into such a position as to prevent the rotation of the barrel; but this obstruction being removed, the barrel rotates so long as the weight descends; and this rotation is communicated, by toothed wheels, to other mechanism. When the weight descends to the floor, or when all the cord is unwound from the barrel, the clock must stop; but before this time arrives the machine is wound up by causing the barrel to rotate in an opposite direction, by which the cord becomes rewound upon it, and the weight elevated.

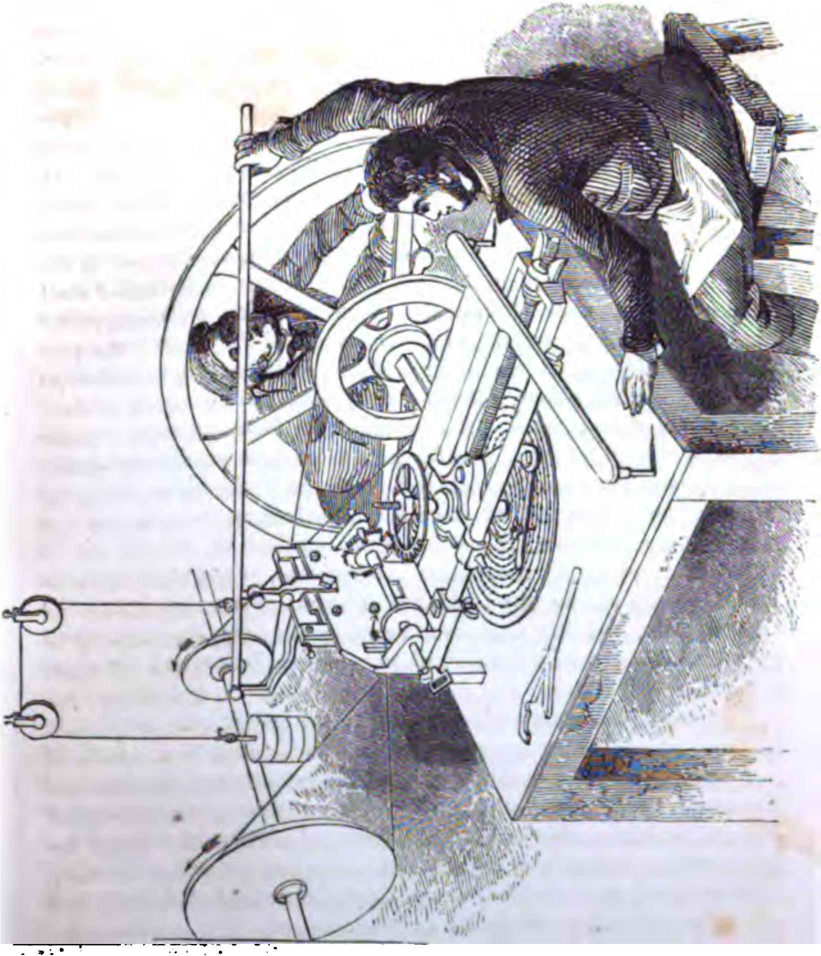
In a house-clock the weight is so small that the winding-up is effected easily by pulling a small handle; but in larger clocks the aid of a winch or windlass is required. The length of the cord is proportioned to the diameter of the barrel, and to the time which the clock is intended to 'go' between each two windings; and is, in a church-clock, very considerable. At the Limehouse clock, which was made three or four years ago by Messrs. Moore, the time of going is, as in most church-clocks, eight days, and the weight by which the barrel is made to rotate amounts to about sixty pounds. The line does not fall perpendicularly from the clock to the weight, but passes over two or three pulleys, for economy of space.

2nd. The '*movement*,' or the going-train of wheels. The makers of clocks and watches apply the name of the 'movement' to the assemblage of wheels which are put in motion by the moving-power. Technically, those wheels which are connected immediately with the hands, with the pendulum, or with the striking machinery, are excluded from this group; but our purpose here is to say a few words respecting the wheel-work generally.

Almost every wheel in a clock has teeth or notches cut in its circumference. Sometimes these teeth stand out radially from the edge; sometimes they are perpendicular to the plane of the wheel; sometimes they nearly resemble the teeth of a saw; but, whatever be the varieties, a glance at the interior of a clock or watch will show that almost every one has these indentations in some form or other. This is one of the modes adopted in general mechanism, for communicating motion from one wheel to another; pulleys, straps, and bands being inconsistent with the minuteness of a clock or watch. In some cases two adjoining wheels work into each other, the teeth of one interlocking in those of the other; but in other cases a small number of teeth are cut in the pinion or axis of one wheel, which work in the teeth at the circumference of the other wheel; and indeed it is in this latter way that a difference of velocity is generally attained. If, for instance, a wheel with fifty teeth work into a pinion of ten teeth, the pinion will rotate five times as fast as the wheel, and thus becomes a source of higher velocity. The great point of attainment in the 'movement' of a clock or watch is, that one particular wheel shall rotate exactly once in an hour; this being effected, the arrangement of the hour and minute hands becomes easily determined. The proportions of the teeth in all the wheels and pinions are therefore so determined as to lead to this rate of movement. In the Limehouse clock the barrel, which is a solid cylindrical block of elm, about eighteen inches in diameter, is attached at one end to a toothed wheel, about two feet in diameter, which rotates with it; and this rotating wheel forms one in a train which leads to the hourly rotation of one particular wheel.

The manufacture of the 'movement' or 'going-train' of a clock or watch consists, therefore, principally in the careful preparation of toothed wheels and pinions. These wheels are made sometimes of brass, and in others of gun-metal, while the pinions are of case-hardened steel. With respect to the factory before mentioned, the wheels are brought thither in a very rough state, just as they are produced by the caster or founder, consisting merely of a circular rim, connected more or less with the central part through which the axis is to pass. The whole manufacture of the wheel from this rude germ is then effected in the shops of the factory. There are lathes for giving to the wheel a perfectly true periphery, by means of sharp steel tools; various pieces of mechanism for shaping, smoothing, and polishing every part of the surface; and, lastly, two very beautiful engines for cutting the teeth.

Of these two engines, one is moved by a foot-treadle, and the other by a winch-handle; but the essential mechanism is the same in both. One of the engines is represented in Fig. 2. There is one part of the mechanism for cutting the teeth, and another for regulating their distance one from another. A horizontal rod or bar is made to rotate



Wheel-cutting Engine.—Fig. 2.

on its axis with great rapidity; and at one part of its surface is fixed either a wheel or a small sharp piece of steel, corresponding in shape to the teeth about to be cut in the brass wheel. The latter is fixed horizontally on a stand, at such a distance from the cutter that the latter can just reach it in the course of its rotation. The amazing rapidity with which the cutter rotates enables it to cut through the brass with great ease, the pressure or contact being regulated by a lever which the workman moves with his right hand. Cutters of various shapes and sizes, but all made of hardened steel, are provided for the cutting of different kinds of teeth. When one tooth is cut, the workman shifts the wheel round a little, to present a new portion of the circumference to the action of the cutter; only one tooth being cut at a time. The extent of this shifting is managed thus:—A brass plate, lying horizontally on the bed of the engine, is marked with a great number of concentric circles, each of which is divided into a number of precisely equal parts, the number being different in the different circles. One circle, for instance, is divided into forty-eight parts, another sixty-four, a third seventy-two, and so on, as may be found most advantageous. If a wheel is to have any number—say sixty-four—teeth in its circumference, a lever is so adjusted that a sharp point at its extremity shall just reach the circle which is divided into sixty-four parts, and as there is a little hole made in the plate at each of these divisions, the sharp point attached to the end of the lever will drop into all these holes in succession, as the plate revolves. The revolution of the wheel which is to be cut causes also that of the divided plate, and the workman knows, by the dropping of the sharp point into one of the little holes, when he has shifted round the wheel to a sufficient distance.

No one who has not closely attended to the matter can conceive the difficulty which has been experienced in thus dividing circles into any number of rigorously equal parts. All the resources of art shown by Ramsden, Troughton, and other eminent mathematical instrument-makers, have been required in the division of circles for astronomical instruments; and although such strict accuracy is not required in common clock and watch wheel-work, yet the amount of skill required and shown therein is sufficiently striking.

Whether the teeth be cut in brass, in gun-metal, in iron, or in steel, whether they are in the wheel itself or in the pinion, and whatever their shape may be, the cutting is effected nearly in the same way, and is succeeded by various finishing and polishing processes requisite for the accuracy of the wheel's motion. Here then we may leave them and proceed to, 3rd. The *indication*, or mechanism connected with the hands. The dial-plate, or rather face, of a large church-clock is generally of wide dimensions, as a means of making its indications conspicuous from below. The four clock-faces at Limehouse church, for example, are each thirteen feet in diameter, with hands and figures of proportionate size. The hands are made of copper, and weigh about sixty pounds the pair. Each hand has, at the extremity opposite to the pointed end, a heavy piece of copper sufficient to act as a counterbalance, and to allow the hand to obey the motion of its axis: this counterbalance is generally painted black, to render it less visible. The arrangement of the mechanism connected with the hands may perhaps be understood from the following description. It will be seen in the frontispiece that at the upper part of the clock is a horizontal wheel, which gives motion to four wheels at right angles to it. These four wheels are connected respectively with the four horizontal rods which proceed from the clock to the faces. Each of these rods (about eight feet long and three-quarters of an inch thick) rotates once in an hour, and communicates that rate of motion to the axis or pinion on which the minute-hand is placed. Other wheel-and-pinion work so modifies this motion as to make another axis rotate once in twelve hours; and on this latter is fixed the hour-hand. It will therefore be seen that the sole source of the movement of the hands is the rotation of the iron rods which extend across the clock-room, and that the mechanism of the clock sets these rods revolving.

Of the face itself we may observe, that in most instances it is made of copper, painted and gilt in a more or less ornamental manner. Others are made of slate; and in some cases the face consists of a circular depression cut in the stone-work of the clock-tower, with figures either painted and gilt on the stone, or cut in relief. The making of the wheels and pinions connected with the clock-face is the work of the same class of persons as those employed in the 'movement' wheels; while the decorative parts devolve upon the 'clock-face gilder.' The dial-plates used for the smaller kind of clocks are very different from these: in some cases they are made of brass, brought to a fine surface, and silvered, with figures and inscriptions cut in the metal by the 'clock-engraver;' while in other instances the face is made of sheet-copper, coated with enamel, and having figures and letters painted in enamel of a different colour, the work of the 'dial-plate enameller' and the 'enamel-painter.'

4th. The *regulation*, or pendulum arrangements. We cannot perhaps better illustrate the use of these portions of a clock's mechanism than by answering the following question: Why does not a clock run down in a few hours, when so heavy a weight as sixty or seventy pounds is constantly urging it? Such would be the case if there were no regulating machinery. In a common vertical pocket-watch we see under a perforated cover a bright steel wheel rotating, or rather vibrating, horizontally; in a common clock we see, instead of this, a pendulum oscillating to and fro. The mechanism in the first case is known by the general name of the *'scapement;* and however different in appearance, the object is the same as that attained by the pendulum of a clock. A spring with a given degree of tension, and a pendulum of a given length, each requires a certain time for the performance of an oscillation; and this important law is made to regulate the movements of the wheel-work in a clock or watch. The steel wheel in a watch is called the 'balance-wheel,' and is governed by a fine spring lying beneath it; but we will here confine ourselves to the pendulum arrangements of a clock. All church-clocks have a long wooden pendulum or staff, to the lower end of which a mass of iron is attached. In the Limehouse clock, for example, the pendulum rod is about thirteen or fourteen feet long, and to the lower end of it is attached a mass of cast-iron shaped like a double-convex lens, about thirty inches in diameter, and weighing two hundred pounds. This is suspended from the frame-work above, and acts in the following manner:—As the wheels revolve, one part of the mechanism gives an impulse to the pendulum, by which it is set in motion. As soon as that impulse has ceased, another urges the pendulum in the opposite direction, and thus the oscillations are produced. But as the pendulum, from the law which governs its movements, has a tendency to make all its oscillations in equal time, it acts as a regulator to the motion of the wheels, and gives it uniformity. In the same manner as a ball, rolling down an inclined plane, would move more and more rapidly every second, so would the rotation of the wheels in a clock increase in rapidity every second, were it not that the pendulum absorbs, as it were, all this increase of velocity by increasing its own extent of oscillation, leaving the *time* between every two oscillations unaltered. It is this equality of time in the movements of the pendulum which produces and maintains equality in the movements of the wheels.

The mechanism connected with the pendulum is not very extensive.

The rod is a plain piece of wood, squared and smoothed for the purpose. The mass of iron, or 'bob,' is cast to the required shape and size, and has an adjusting arrangement by which it can be attached to the rod at any part of its height. In some church-clocks there is a graduated arc to measure the extent of the vibrations, which varies with the moving-power. At the upper end of the pendulum are small pieces of mechanism, in iron and brass, by which the rod is brought under the influence of the wheel-work, and set into oscillation. The 'bob' of a church-clock pendulum, from the necessary length of the rod, is in most cases beneath the room in which the clock itself is contained.

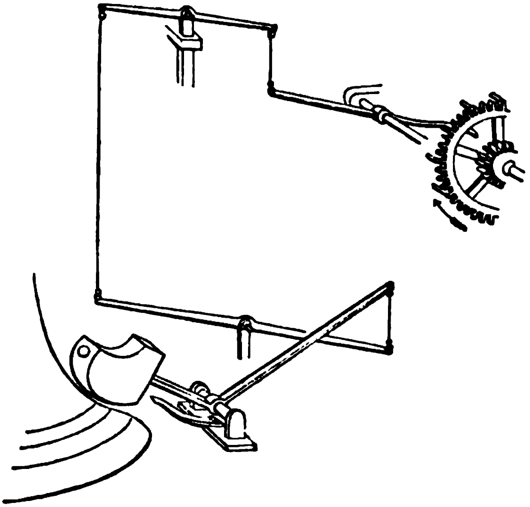
5th. The *striking* machinery. Our clock has hitherto been a silent monitor. We have offered a few items of explanation as to the manner in which it shows to the eye the progress of time; but there is an appeal to the ear which is equally worthy of notice. Every one knows that church-clocks differ greatly in the number and frequency of the sounds emitted from the bells. Many clocks only strike the hour, proportioning the number of strokes to the hour of the day; others, in addition to this, announce the quarters, by two, four, eight, or some other number of bells, all bearing a certain musical relation one to another; and a third kind play some particular hymn or melody at certain intervals of time, on eight or ten bells. But all church-clocks, with very rare exceptions indeed, have a bell on which the hour is struck.

It will easily be conceived that if a bell be hung in a particular spot, and a lever with a hammer at the end be placed near the bell, the lever may without difficulty be so influenced by the wheels of the clock as to cause the hammer to strike the bell. But to cause exactly an interval of an hour to elapse between two such strikings, and to make the number of blows on each occasion correspond with the hour of the day, require mechanism almost as complicated as that by which the indications of the hands are produced. Still greater is this complication when the clocks chime the quarters; and when a regular melody is performed on the bells, the arrangements are proportionally more intricate.

In the first place it must be clearly borne in mind that there is a separate moving-power for the striking-machinery, similar in principle to that which impels the going-train. In an eight-day dial, for example, there is one spring-barrel and fusee for the going-train, and another, nearly the same in form and size, for the striking-train. In a church-clock, and in common Dutch clocks, there is one iron weight for the going-train and another for the striking-train, each weight having a cord and barrel appropriated to itself. If we notice the movements of a common domestic pendulum-clock, we shall see that while one of the two weights is continually descending at a slow rate, the other descends only while the clock is striking: it is the descent of the last-named weight which causes the striking of the clock, and this striking would be continuous if there were not checks to the descent of the weight. For a large church-clock, where the tones of the bell could not be clearly elicited, except by blows from a heavy hammer, the moving-power of the striking-machinery greatly exceeds that of the going-train. In the Limehouse clock the going-weight is about sixty pounds, whereas the striking-weight is a mass of iron weighing five hundred pounds, and the hammer-head fifty-six pounds. This heavy mass is attached to a rope which winds round a solid wooden barrel, of nearly the same diameter as the barrel before mentioned, and this barrel gives motion to a train of wheels by the customary tooth-and-pinion work. The motion, however, is checked by a catch or detent, except at the termination of each hour, when a curious piece of mechanism connected with the going-train releases the striking-machinery, allows the weight to descend, and causes the hammer to strike the bell. Whether the bell be above, below, or at the side of the clock, the connection between the striking-wheels and the hammer is easily made by levers and pulleys: at the Limehouse clock the bell is beneath the other parts of the mechanism. The mechanism in immediate connection with the hammer and bell of the Limehouse clock is shown in Fig. 3.

But although the release of the striking-machinery causes the descent of the weight and the percussion of the bell, yet this does not determine whether the strokes shall be one or many. This is determined principally by two pieces of mechanism called a 'snail' and a 'rack,' the intricate action of which it would be in vain to attempt to explain here. Suffice it to say, that the time during which the striking-weight is allowed to descend, varies at different hours of the day; it being sometimes only long enough to permit one blow to be given by the hammer on the bell, and at another time long enough for twelve such blows.

When the clock indicates the quarter-hours on two or more bells, an additional piece of mechanism is necessary, which releases the



Striking-apparatus of a Turret-Clock.—Fig. 3.

hammers of those bells every fifteen minutes. If the bells are so numerous, and the mechanism so elaborate, as to produce a musical chime or a melody at stated intervals, then we have those well-known effects with which the poet and the peasant are equally familiar—effects which many have felt as well as Cowper, but which few can express so well:—

> "How soft the music of those village bells,
> Falling at intervals upon the ear
> In cadence sweet! now dying all away,
> Now pealing loud again and louder still,
> Clear and sonorous as the gale comes on."

The merry peal which marks the holiday or the day of festivity is, as we have before observed, not rung by machinery connected with the church-clock, but by men, who pull ropes by which hammers are made to strike on a set of bells; each man attending to one bell, and the whole regulating their proceedings according to the rules of the curious art of bell-ringing. But where a melody is performed at fixed hours every day, then are the bells sounded by mechanism connected with the clock. He who hears the 149th Psalm played on the bells of St. Clement's church, or the other tunes on the bells of two or three other metropolitan churches, must not confound these performances with the ringing of a *peal* of bells.

In some churches, the bells play only one tune, at certain fixed hours of the day; in others, there are seven different tunes played, one for every day of the week, each tune being repeated either six or eight times within the day to which it belongs. Such is the case in a clock constructed for Christchurch, Hampshire, about five or six years ago: there is an octave of eight bells, which play seven different tunes, the tune being changed at midday. There are, we believe, two similar instances in London.

How are these tunes played? Such a question has doubtless occurred to many persons, and is deserving of an answer. If the reader has any idea of the mode in which a musical snuff-box acts, he will not find it difficult to understand the present matter. In a musical-clock, as in a musical-box, there is a barrel studded in various parts of its surface with small pins or pieces of wire, placed apparently in a most unsymmetrical manner. These pins, during the rotation of the barrel, come in contact with small springs in the musical-box; but in the clock they catch against small levers connected with the hammers which strike the bells. Every pin moves a lever with sufficient force to enable the hammer to strike the bell; and therefore the artist's object is to place the pins in such order on the surface of the barrel as to lead to the striking of the bells in the proper order to form a tune, the bells being attuned to regular musical intervals.

In modern church-clock factories the 'pricking' of the barrel, or the insertion of the pins in their proper places, is effected by a very beautiful machine; but a description of the old method adopted, though too rude for modern purposes, will perhaps be more readily understood by persons unaccustomed to machinery. A piece of writing-paper was taken, of such a size as to cover exactly the surface of the barrel; and on this were drawn, in a direction perpendicular to the axis of the barrel, as many parallel lines as there were notes in the tune, the lines being equidistant and corresponding to the levers which moved the hammers. They were marked at each end with the letters or notes of the gamut which they represented; and, according to the number of bars in the tune, as many spaces were made by lines drawn equidistant and parallel, intersecting the others at right angles. The junction of the ends of the paper, when applied round the barrel, represented one of these bar-lines. The spaces were again divided into smaller parts, for the minims, crotchets, and other notes in the tune, by lines parallel with the axis of the barrel. While the paper was lying on the table, the notes in the tune proposed to be laid on the barrel were marked by black ink dots on their respective lines, and in the same order as the bars of the music. After this was done, the paper was pasted on the barrel; and the note-lines then appeared like so many circles traced round the circumference of the barrel, while the bar-lines lay longitudinally on the surface of it. By this means the black ink dots were transferred and marked on the barrel by a punch or finger-drill, and the pins inserted at those spots.*

But where many tunes are played by one barrel, this primitive mode is inefficient. The principle, however, may be understood from it. The barrels 'pricked' for several tunes by the modern machine are so connected with the mechanism of the clock as to shift a little when the tune is changed, so that the hammers may be acted on by a different set of pins from those in use during the performance of the former tune: indeed, this shifting of the barrel is the circumstance which changes the tune.

So far we have glanced over the main parts of the mechanism of a clock; but we cannot treat of the 'striking' machinery without devoting a page or two to the bells themselves, the vast sonorous masses for the sounding of which so much mechanism is required. This will take us from the clock-factory to the church-bell foundry, of which the only one in London is that of Messrs. Mears in Whitechapel.

All bells are made of a compound of copper and tin, and all are cast in moulds. A bell-foundry exhibits an earthen floor, excavated in parts to a depth of several feet, and having furnaces in which the metal is melted. At Messrs. Mears's foundry there is one furnace which will melt ten tons of metal at once, and another of smaller size. In this larger furnace was melted the metal for the "Great Tom of Lincoln," the largest bell in England except the "Great Tom of Oxford." The latter weighs seventeen thousand pounds, whereas the great bell of St. Paul's amounts only to between eleven and twelve thousand pounds. The new "Great Tom of Lincoln" (twelve thousand pounds) replaced, in the year 1835, the old bell of the same name, which was not so heavy by a ton. The thickness of the metal in bells of this kind varies so greatly that the weight cannot be judged from their size. St. Paul's bell, for example, is much larger than the "Great Tom of Lincoln," but is not so heavy; but all the weights here indicated sink into insignificance when compared with that of some of the Russian bells, five of which weigh respectively 50,000, 124,000, 144,000, 288,000, and 432,000 lbs.

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* Reid, 'Treatise on Clock and Watch Making.'

Both the shape of the bell and the proportions of the two metals are regulated so as to produce the most sonorous effects. The metal consists of four parts of copper to one of tin. The tin is usually brought to the foundry in blocks from the mining districts, and the copper is old ship-sheathing and other fragments. These two metals are melted together in a reverberatory furnace, that is, one in which the flame and heated air pass over and upon the substance to be melted, instead of being applied underneath it. A very large volume of flame is kept up from a fire of dry billet-wood, and the heat from this is found to be less injurious to the metal than that of a common furnace. The metal remains in the furnace till it assumes the appearance of liquid fire, when it is ready for casting.

The mould into which the metals flow to form the bell is thus made:—A rough centre is built up of brickwork, at the bottom of a pit adjacent to the furnace, the mass being somewhat smaller than the interior diameter of the bell. This is coated with a particular kind of clay, which is shaped by gauges to the exact size and form of the interior of the bell; and on its surface is stamped any device which is to appear on that interior. This heart or core is then thoroughly dried, preparatory to the application of another layer of composition. The second layer is exactly the thickness of the intended bell; and is moulded, by gauges and other tools, till its outer surface presents precisely the size, form, and device of the intended exterior of the bell. A little dry tan-dust is sprinkled on the core previous to the application of this second layer, in order that the two portions of clay or earth may not adhere too closely. Matters are now ready for the application of a third layer of clay. This is of considerable thickness, and is laid over the intermediate stratum of clay, with a sprinkling of tan-dust, as in the former case. All these arrangements being made, and the clay thoroughly dried, the outer layer or case is lifted off the intermediate one, and the latter is picked or cut off the inner one piecemeal. The effect which is produced by these contrivances may be thus illustrated:—If we take three basins or cups of different sizes, and invert them one over another, we may represent the bell-mould in its built-up form; but if the *middle* basin be removed, there will be a vacancy between the other two. The vacancy thus produced in the bell-mould is that into which the metal is poured, a hole being left at the top for that purpose, and two others for the escape of air as the metal enters.

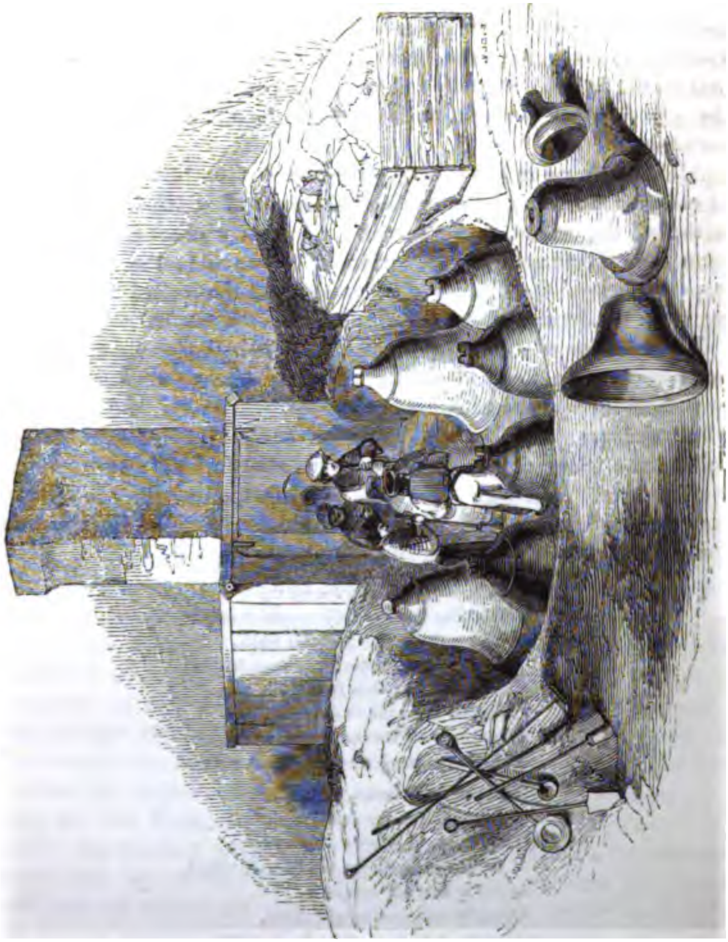
All this is done in the casting-pit, which is then filled up with loam or earth to the top of the mould, the height of which is nearly equal to that of the orifice in the furnace. A shallow channel is cut in the loam from the furnace to the orifice of the mould; the earth which stops the hole in the furnace is cut away; and the melted metal, flowing from the furnace along the channel, fills the mould.

In some parts of Germany the casting of a bell is made a matter of much ceremony; the bell-founder inviting a large circle of friends to witness the scene, which commences with a prayer, and terminates with rejoicing. Schiller made this the subject of one of his finest ballads, the 'Song of the Bell,' many stanzas of which vividly portray the process of founding. We may select two, as relating, the first to the appearance of the pit when the mould or moulds are earthed in, and the second to the melting of the metal:—

"Fast immured within the earth,
  Fix'd by fire the clay-mould stands:
This day the bell expects its birth,
  Courage, comrades! ply your hands.
Comrades! ceaseless from your brow,
Ceaseless must the sweat-drop flow.
If by his work the master 's known,
Yet Heaven must send the blessing down.

Billet of the fir-wood take,
  Every billet dry and sound,
That flame, a gather'd flame awake,
  And vault with fire the furnace round.
Quickly cast the copper in,
Quickly cast due weight of tin,
That the bell's tenacious food
Rightly flow in order'd mood."

In Fig. 4 the casting-pit is represented with seven bell-moulds, for the casting of the same number of bells. We saw these bells cast a few days after the drawing was made, the pit having been filled with loam in the interim. It is a sight worth a visit to see the furnace full of liquid fiery white metal, the narrow jet pouring out at



Casting-pit of a Bell-Foundry.—Fig. 4.

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into smaller parts, for the minims, crotchets, and other notes in the tune, by lines parallel with the axis of the barrel. While the paper was lying on the table, the notes in the tune proposed to be laid on the barrel were marked by black ink dots on their respective lines, and in the same order as the bars of the music. After this was done, the paper was pasted on the barrel; and the note-lines then appeared like so many circles traced round the circumference of the barrel, while the bar-lines lay longitudinally on the surface of it. By this means the black ink dots were transferred and marked on the barrel by a punch or finger-drill, and the pins inserted at those spots.*

But where many tunes are played by one barrel, this primitive mode is inefficient. The principle, however, may be understood from it. The barrels 'pricked' for several tunes by the modern machine are so connected with the mechanism of the clock as to shift a little when the tune is changed, so that the hammers may be acted on by a different set of pins from those in use during the performance of the former tune: indeed, this shifting of the barrel is the circumstance which changes the tune.

So far we have glanced over the main parts of the mechanism of a clock; but we cannot treat of the 'striking' machinery without devoting a page or two to the bells themselves, the vast sonorous masses for the sounding of which so much mechanism is required. This will take us from the clock-factory to the church-bell foundry, of which the only one in London is that of Messrs. Mears in Whitechapel.

All bells are made of a compound of copper and tin, and all are cast in moulds. A bell-foundry exhibits an earthen floor, excavated in parts to a depth of several feet, and having furnaces in which the metal is melted. At Messrs. Mears's foundry there is one furnace which will melt ten tons of metal at once, and another of smaller size. In this larger furnace was melted the metal for the "Great Tom of Lincoln," the largest bell in England except the "Great Tom of Oxford." The latter weighs seventeen thousand pounds, whereas the great bell of St. Paul's amounts only to between eleven and twelve thousand pounds. The new "Great Tom of Lincoln" (twelve thousand pounds) replaced, in the year 1835, the old bell of the same name, which was not so heavy by a ton. The thickness of the metal in bells of this kind varies so greatly that the weight cannot be judged from their size. St. Paul's bell, for example, is much larger than the "Great Tom of Lincoln," but is not so heavy; but all the weights here indicated sink into insignificance when compared with that of some of the Russian bells, five of which weigh respectively 50,000, 124,000, 144,000, 288,000, and 432,000 lbs.

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* Reid, 'Treatise on Clock and Watch Making.'

Both the shape of the bell and the proportions of the two metals are regulated so as to produce the most sonorous effects. The metal consists of four parts of copper to one of tin. The tin is usually brought to the foundry in blocks from the mining districts, and the copper is old ship-sheathing and other fragments. These two metals are melted together in a reverberatory furnace, that is, one in which the flame and heated air pass over and upon the substance to be melted, instead of being applied underneath it. A very large volume of flame is kept up from a fire of dry billet-wood, and the heat from this is found to be less injurious to the metal than that of a common furnace. The metal remains in the furnace till it assumes the appearance of liquid fire, when it is ready for casting.

The mould into which the metals flow to form the bell is thus made:—A rough centre is built up of brickwork, at the bottom of a pit adjacent to the furnace, the mass being somewhat smaller than the interior diameter of the bell. This is coated with a particular kind of clay, which is shaped by gauges to the exact size and form of the interior of the bell; and on its surface is stamped any device which is to appear on that interior. This heart or core is then thoroughly dried, preparatory to the application of another layer of composition. The second layer is exactly the thickness of the intended bell; and is moulded, by gauges and other tools, till its outer surface presents precisely the size, form, and device of the intended exterior of the bell. A little dry tan-dust is sprinkled on the core previous to the application of this second layer, in order that the two portions of clay or earth may not adhere too closely. Matters are now ready for the application of a third layer of clay. This is of considerable thickness, and is laid over the intermediate stratum of clay, with a sprinkling of tan-dust, as in the former case. All these arrangements being made, and the clay thoroughly dried, the outer layer or case is lifted off the intermediate one, and the latter is picked or cut off the inner one piecemeal. The effect which is produced by these contrivances may be thus illustrated:—If we take three basins or cups of different sizes, and invert them one over another, we may represent the bell-mould in its built-up form; but if the *middle* basin be removed, there will be a vacancy between the other two. The vacancy thus produced in the bell-mould is that into which the metal is poured, a hole being left at the top for that purpose, and two others for the escape of air as the metal enters.

All this is done in the casting-pit, which is then filled up with loam or earth to the top of the mould, the height of which is nearly equal to that of the orifice in the furnace. A shallow channel is cut in the loam from the furnace to the orifice of the mould; the earth which stops the hole in the furnace is cut away; and the melted metal, flowing from the furnace along the channel, fills the mould.

In some parts of Germany the casting of a bell is made a matter of much ceremony; the bell-founder inviting a large circle of friends to witness the scene, which commences with a prayer, and terminates with rejoicing. Schiller made this the subject of one of his finest ballads, the 'Song of the Bell,' many stanzas of which vividly portray the process of founding. We may select two, as relating, the first to the appearance of the pit when the mould or moulds are earthed in, and the second to the melting of the metal:—

"Fast immured within the earth,
Fix'd by fire the clay-mould stands:
This day the bell expects its birth,
Courage, comrades! ply your hands.
Comrades! ceaseless from your brow,
Ceaseless must the sweat-drop flow.
If by his work the master 's known,
Yet Heaven must send the blessing down.

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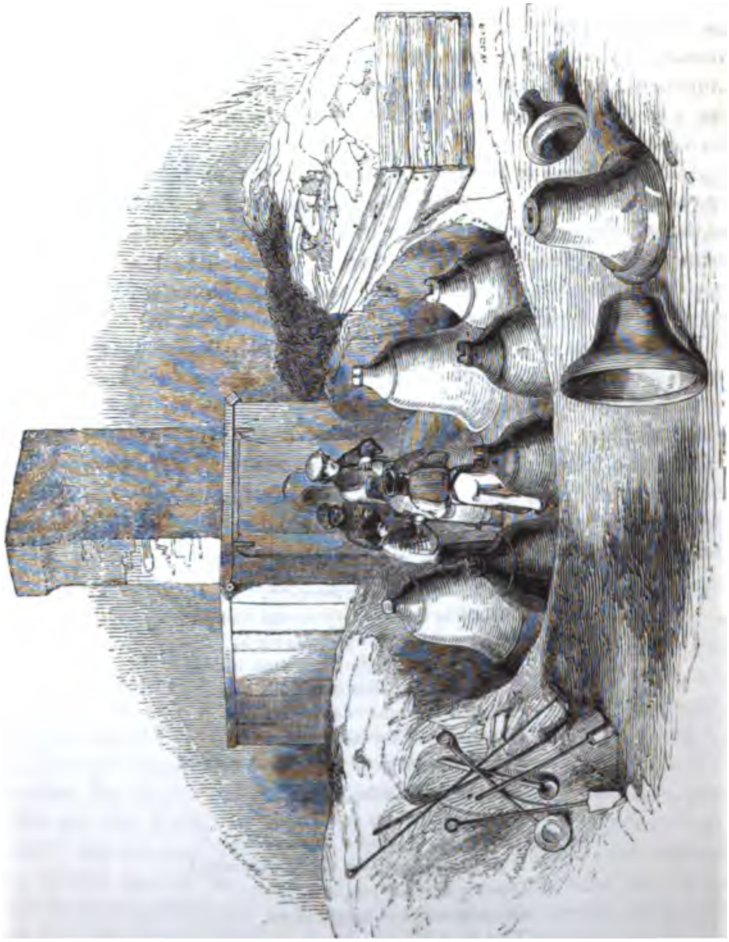

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The bell is cast in a complete state, but it requires a little adjustment to regulate its tone. If a set of bells are to be made, having intervals of tones and semitones, the requisite adjustment is made by reducing the diameter at the edge when the tone is too low, and reducing the thickness at the part where the hammer strikes when the tone is too acute. This reduction is made by chipping away the metal with a sharp-pointed hammer—a process as intensely noisy, perhaps, as any which our manufactures present, excepting (and we really must make the exception) the operations in the steam-boiler factory in Woolwich Dock-Yard.

XV.—A DAY AT A PRINTING-OFFICE.

Among all the manufactures which—for the mental and mechanical skill required in their prosecution, the remarkable steps by which they have attained their present rank, and the influence which they exert on society generally—claim our attention and admiration, none perhaps is more striking than the *manufacture of a book*. The written thoughts of those whose thoughts were worthy of being known used to be transcribed, copy after copy, by the hands of monks and laborious students; and these copies were prized according to the labour bestowed upon them, irrespective, in many cases, of the literary merits of the production. But the introduction of printing changed the nature of this valuation. The larger the number of *written* copies required, the higher would be the price of each, because the demand for transcribers' labour would be increased; but the larger the number of *printed* copies demanded, the cheaper could each one be furnished, because machinery and the classification of labour could be brought more effectually into operation. The process of printing, when compared with that of writing, is unquestionably a cheap one, provided a sufficient number of copies of any particular book be printed, so as to distribute the original outlay over a large circle. If, for example, it were required, even at the present time, to print three or four copies only of any production, the cost of printing would be greater than that of transcribing. It is only when hundreds or thousands of copies are required that the paramount importance of the printing press becomes fully developed; and when the sale amounts to tens of thousands, the effect upon the *price* of each copy becomes very remarkable.

These matters belong properly to the history of printing; but it may be worth while to allude to them here, as a means of accounting for the growth of the vast printing establishments in operation at the present day. Whether we say that cheap literature has given a spur to printing, or that printing has given a spur to cheap literature, or, which is perhaps the most correct of the three, that each has received advancement from the other, it is clear that the printing establishments of the present day excel, both in extent and completeness, those of any former period. To one of these establishments, then, viz., that of Messrs. Clowes, we will pay a visit, and endeavour to understand the rationale of the daily operations.

This printing-office occupies a large area of ground westward of Duke Street, Stamford Street. A chimney rears its head from the buildings below, and indicates the locality; but the vicinity of other chimneys—belonging to a soap factory in one place, a saw-mill in another, and so forth—might render this a treacherous beacon, so we will discard it, and find our way to the entrance of the factory. Within side the gates, masses of buildings present themselves on all sides. Unlike many factories where an open area or court occupies the central portion between the buildings, this establishment has distinct masses of buildings lying in various directions, and separated by narrow passages, instead of an open court. The truth seems to be that, in proportion as the business has increased, every inch of room has been appropriated. We may, however, pick out the topography of the place in something like the following manner. In the centre of the whole factory is a low building, containing the greater number of the large printing machines belonging to the establishment, together with an engine-room and other factory appurtenances. Looking from this centre towards the north, south, east, and west, loftier buildings meet the eye, presenting, as it would appear, no particular symmetry of arrangement, but adapted to the wants and conveniences of the time. Composing-rooms, readers'-rooms, type-making shops, stereotyping shops, paper-warehouses, hand-printing shops, machine-printing shops, wood-block store-rooms, stereotype-plate store-rooms,—these comprise the dense assemblage which the eye glances on around. These we will visit in the order of processes, premising that this is one of the very few printing establishments (the only one, indeed, as far as we are aware) in which type-making or casting is carried on.

In one tiny room, small indeed compared with the importance of the process carried on therein, the first germ of a type is produced. Every one knows that the printed letters of a book are produced by small inked types, each of which has a letter *in relievo* on one end. But how this type is produced may have been with many a question. Is it cut with sharp tools, or is it cast in a mould? When we even go one step further back, and state that it is cast in a mould, it may

When the punch has formed the *matrix*, or hole in the little slip of copper, we follow the latter into the 'type-foundry,' a double apartment, containing about thirty men and boys making and trimming types. In the two halves of the shop, separated by a partition and doorway, we see about sixteen or eighteen small furnaces, each about a yard in height, and having at the top a pan or crucible capable of containing a few pounds of melted metal. Near each of these furnaces a man is at work; but a stranger cannot form the remotest idea at first what these men are about. The left arm, eight or ten times in a minute, is suddenly jerked upwards; the right hand is, with the same rapidity, passed to and fro; and a small machine seems to be undergoing some kind of adjustment after every upward jerking of the left arm. This operation, when once understood, can scarcely fail of being deemed one of the most remarkable instances of manipulative dexterity. In the *eighth part of a minute* each man lades a very small quantity of melted metal out of the crucible or pan, pours it into a mould held in the left hand, jerks the mould upwards to drive the metal into the minute interstices of the mould, opens the mould, extracts the solidified but still heated type, and prepares the mould for a second casting. That all this can be done in seven or eight seconds is a fact so astonishing that even ocular demonstration scarcely removes incredulity; and yet the heap of made-type gradually accumulates on the bench of the workman, at the rate of four or five hundred an hour!

When we examine this process more closely, we find that the mould or instrument held in the left hand of the workman is a very ingenious little contrivance, formed as in Fig. 1.

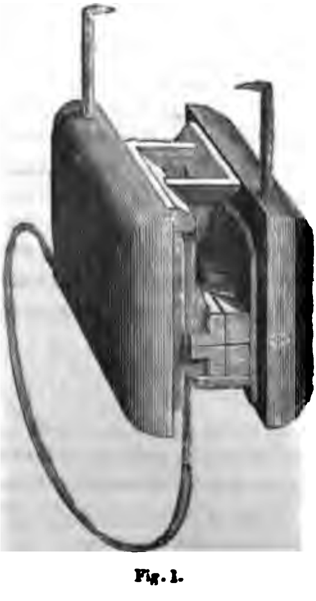


Fig. 1.

The mould is composed of two parts. The external surface is of wood, the internal of steel. At the top, as will be seen by the cut, is a shelving orifice, into which the metal is poured. The space within is as true as if it had been hollowed out of a single piece of steel; but nevertheless it is formed by the intimate union of the two parts of the mould, each part forming two of the four sides of the letter. It is not a matter of difficult adjustment to bring these sides together: it is the operation only of an instant. At the bottom of the mould, immediately under the orifice, is the matrix. This is held in its place by a metal spring, represented at the lower part of the cut; and every letter that is cast can only be loosened from the matrix by removing the pressure of the spring. In Fig. 2 there is a representation of three furnaces. At the first, which is unoccupied, may be seen the little table at which the founder works, and the pot out of which he dips the heated metal with a very small ladle. At the second furnace the workman is shown at the moment after he has poured the metal into the mould. And at the third, the other workman is represented in the act of separating the two parts of the mould, and picking out the letter from the lower half, with the hook shown at the top-edge of the other half. It certainly has an appearance not a little remarkable to see twenty men throwing their arms about in apparently a convulsive manner; and the surprise is not by any means lessened when we know the real nature of the operation.

In other parts of these two shops are men and boys who take the types as fast as they are cast, and bring them into a finished state. Seated at a table is a boy who collects in a heap before him the types made by many casters, each type having a piece of superfluous metal attached to its end as it comes out of the mould. It is this boy's business to break off the superfluous metal; and this he does with such rapidity that the mode in which he operates can scarcely be followed by the eye. The average rapidity is two thousand in an hour; bu some boys have been known to break off five thousand types in this space of time. This rapidity is the more remarkable as the boy must seize the type, not upon the flat surface, but upon its edges, to avoid breaking or bending it.

The boys whom we have just left are designated 'breaking-off boys;' and the types pass from them to other boys called 'rubbers,' seated at benches near the range of windows. Each rubber has before him on his bench a circular piece of grit-stone, on which he rubs the sides of every type singly, to remove slight asperities left by the casting; the fingers of his right hand are armed with a piece of tarred leather, with which he holds the type during its rubbing against the stone. Two thousand types are thus rubbed on both sides in an hour.

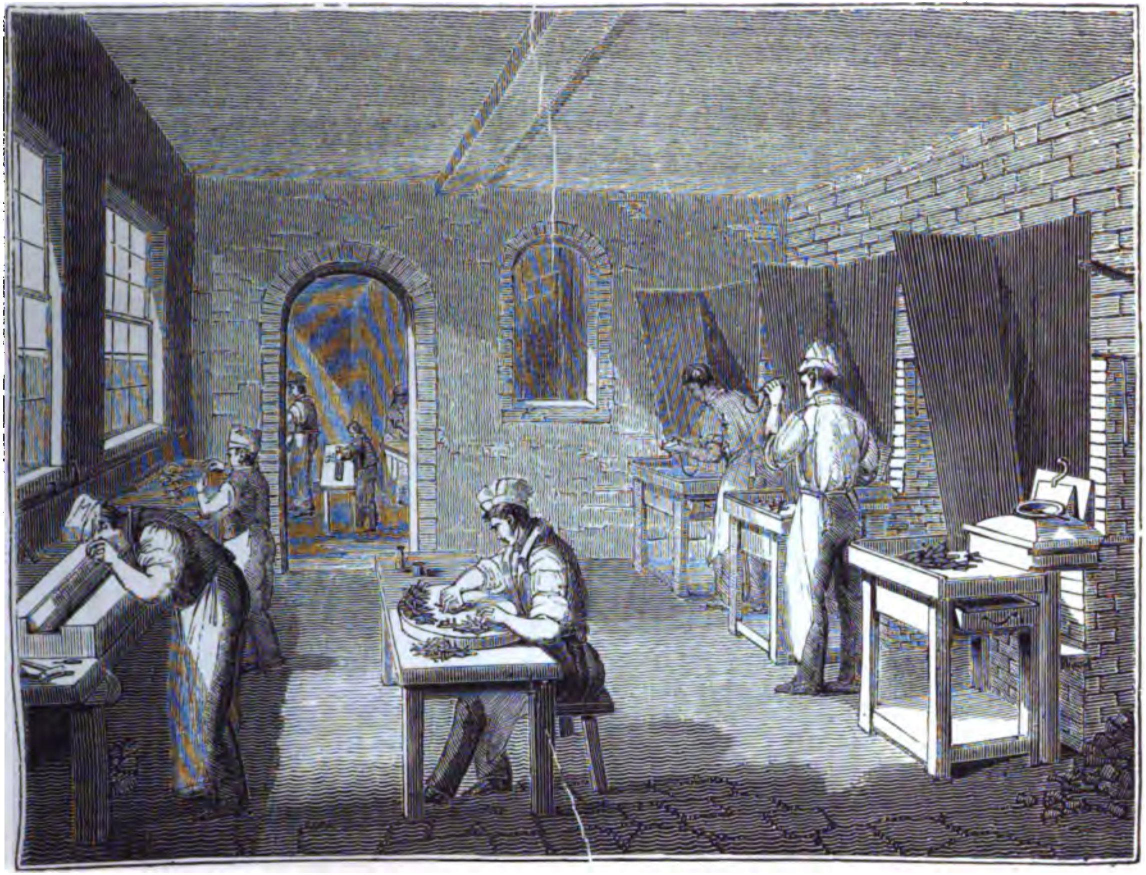
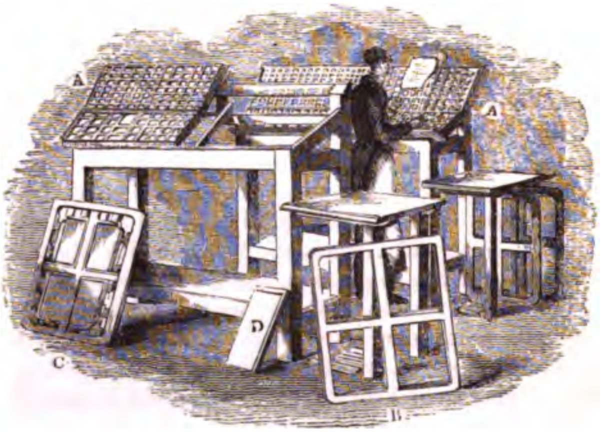


Fig. 2.—Type-Foundry.—Face p. 330.

We have not yet done with this closely-occupied apartment. There is yet the 'dresser' to notice, whose office it is to examine every type, and to bring them all to an equal height. This workman receives from a boy a number of types, all set up in lines in a long shallow frame, with the face of the type uppermost. The workman then secures the types into a compact mass, with the bottom ends uppermost, and runs a plane along them to bring them all to a level surface. He also examines the face or device on every type with a magnifying glass, and throws aside all those which are defective. The width and depth of each type may in all cases be pretty well determined by looking at the size of the individual letters in a printed book, the type being large or small in proportion to the size of the letters; but the *length* of all types is the same, being rather less than an inch. It is easy to see how essential it is that every letter-type should be perfectly square and true, when it is considered that if they were not of uniform height the impression could not be even; and that, if there were the least deviation from a regular form, it would be quite impossible that when many thousand single letters are combined to form the page of a book, they could hold well together.

Leaving the type-foundry, we see, in one of the store-rooms of the establishment, a case or nest of shelves, neither lofty nor large; and yet it contains eighty thousand pounds weight of type. This is called the 'fount-case'—*fount* being a technical term for all the types belonging to one size and character. The fount-case is divided into compartments, each for the reception of a particular letter; and in this case the type is deposited after it leaves the foundry, and before it is consigned to the compositor.

We next visit one of the six compositors' rooms belonging to the establishment, the principal of which is known as the 'long-room.' This remarkable-looking room does not ill deserve its name, for it is more than two hundred and fifty feet in length; and yet it is so narrow that a stranger cannot help fearing that, as he passes along, he must incommode the industrious and intelligent men who are working near his elbow. Along the whole of the south side of the room, from end to end, are arranged small benches or 'frames,' at each of which a compositor is at work; and the compositors thus stand, one before another, to the number of about sixty, with their left hands towards the wall. The opposite side of the room presents here and there 'proof-presses,' for testing the accuracy of the compositor's work;



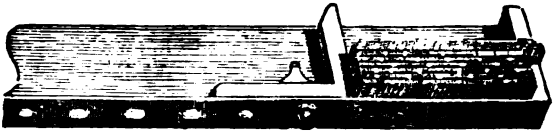
A,A, cases; B, a chase; C, a form of quarto; D, a galley.—Fig. 5.

being formed of 40,000, or 50,000, or even 100,000 moveable pieces. Fig. 5 shews the various pieces of apparatus here alluded to.

Whether the lines which a compositor sets up are made into pages, and *imposed* as a sheet, or whether a proof is taken of them in an earlier stage, the business of the *reader* commences immediately after that of the compositor. No one unacquainted with the details of a printing-office can conceive the great differences between the correctness of one compositor and of another. The differences in the talent, the acquired knowledge, and even the moral habits of different men, are the causes of these remarkable variations.

When the ordinary reader of a newspaper, or of a book, meets with an occasional blunder either of a letter or a word, he is apt to cry out upon the carelessness with which the newspaper or book is printed. It is in the very nature of the process of producing words and sentences by the putting together of moveable types that a great many blunders should be made by the compositor in the first stage, which nothing but the strictest vigilance can detect and get rid of. The ordinary process of correction is for the printer's reader to look upon the proof, while another person, generally a boy, reads the copy aloud. As he proceeds, the reader marks all the errors which present themselves upon a first perusal. These errors are of various kinds; such as the

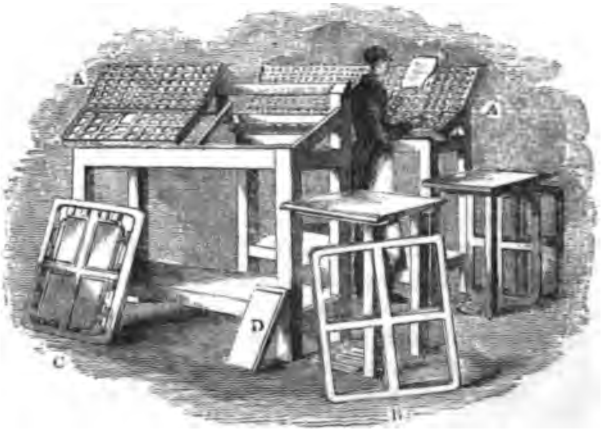
of the page or column which the workman has to set up. It is made perfectly true and square; for without such accuracy the lines would be of unequal length. It is adapted to contain not more than about twelve lines of such type as is employed in this present book. This little instrument is represented in Fig. 4.



Composing-stick.—Fig. 4.

The copy from which the compositor works rests upon the least-used part of the upper case. The practised compositor takes in a line or two at a glance, always provided the author writes an intelligible hand,—which virtue is by no means universal. One by one, then, the compositor puts the letters of each word and sentence into his stick, securing each letter with the thumb of his left hand, which is therefore continually travelling on from the beginning to the end of a line. His right hand goes mechanically to the box which he requires; but his eye is ready to accompany its movements. In each letter there is a nick, or nicks, which indicates the bottom edge of the letter; and the nick must be placed outwards in his composing-stick. Further, the letter must also be placed with the face upwards, so that two right positions must be combined in the arrangement of the types. If the compositor were to pick up the letter at random, he would most probably have to turn it in his hand; and as it is important to save every unnecessary movement, his eye directs him to some one of the heap which lies in the right position, both as regards the face being upwards and the nick being outwards. This nick is one of those pretty contrivances for saving labour which experience has introduced into every art, and which are as valuable for diminishing the cost of production as the more elaborate inventions of machinery. When he arrives at the end of his line, the compositor has a task to perform, in which the carefulness of the workman is greatly exhibited. The first letter and the last must be at the extremities of the line: there can be no spaces left in some instances, and no crowding in others, as we see in the best manuscript. Each metal type is of a constant thickness, as far as regards that particular letter, though all the letters are not of the same thickness. The adjustments, therefore, to complete the line with a word, or, at any rate, with a syllable, must be made by varying the thickness of the spaces between each word. A good compositor is distinguished by uniformity of spacing: he will not allow the words to be very close together in some instances, or with a large gap between them in others. His duty is to equalize the spacing as much as he possibly can; and this is in some cases very troublesome. When the workman has *filled his stick*, as it is called,—that is, has set up as many lines as his stick will conveniently hold,—he lifts them out into what is termed a *galley*, by grasping them with the fingers of each hand, and thus taking them up as if they were a solid piece of metal. The facility with which some compositors can lift about what is called a *handful* of moveable type, without deranging a single letter, is very remarkable. This sort of skill can only be attained by practice; and thus one of the severest mortifications which a learner has to endure is to toil for an hour or two in picking up several thousand letters, and then see the fabric destroyed by his own clumsiness, leading him to mourn over his heap of broken type,—technically called *pie*,—as a child mourns over his fallen house of cards.

Letter by letter, and word by word, is the composing-stick filled; and by the same progression the galley is filled by the contents of successive sticks. In the instance of newspapers and most other periodical works, a proof is taken before the types are made up into pages. In books, however, when the compositor has set up as many lines as fill a page, he binds them tightly round with cord, and places them under his frame. The number of lines required to fill a page depends of course on the size of the page, whether it be octavo, duodecimo, or any other. If we take the present volume as an illustration, we find 39 lines in a page; and the compositor binds this number of lines of type together. In every case when the requisite pages for a sheet are complete, the compositors arrange the pages in proper order upon a bench called the imposing stone; surround each page with pieces of wood called *furniture*, so as to leave an equal margin to every page; and, finally, wedge the whole tightly together in a stout iron frame, called a *chase*. If the work is properly executed, the pages thus wedged up, constituting one side of a sheet, termed a *form*, are perfectly tight and compact; and the *form* may be carried about with as much ease as if it were composed of solid plates, instead of



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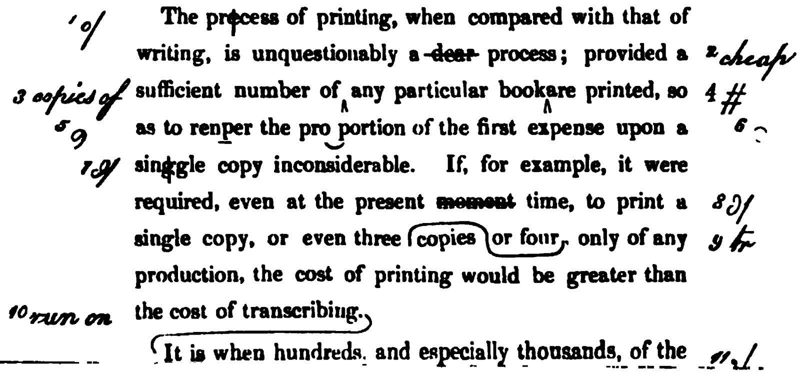

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single copy, or even three copies or four, only of any 9 tr
production, the cost of printing would be greater than
10 run on the cost of transcribing.
It is when hundreds, and especially thousands, of the 11 ./

Fig. 6.—Corrections.—Face p. 341.

omission of a stop, a letter, or a word, the substitution of one letter for another, the transposition of letters, crookedness in a line of letters, and so forth. The reader has a quick and efficient system of symbols by which the compositor's eye is at once attracted to the locality and the precise nature of the error. Perhaps we cannot do better than present, as in the annexed folding-leaf, two printed paragraphs, which we will suppose to have been submitted to the 'reader' for revision. Almost every possible variety of typographical error is here introduced, and in the margin are the marks and directions by which the 'reader' draws the attention of the compositor to the errors. The meaning of the various symbols is explained beneath.

When the 'reader' has made these corrections in the margin, the 'proof' is sent back to the compositor; and here a business of great labour and difficulty ensues. The omitted words and letters have to be introduced, and the incorrect words and letters have to be replaced by the correct. The introduction of two or three words will sometimes derange the order of a dozen lines; and the omission of a sentence will involve the re-arrangement of many pages. In this tedious process new blunders are oftentimes created, and these again can only be remedied by after-vigilance. The first corrections being perfected, the reader has what is called a *revise*. He compares this with his first proof, and ascertains that all his corrections have been properly made. In this stage of the business the proof generally goes to the author; and it is rarely that the most practised author does not feel it necessary to make considerable alterations. The complicated process of correction is again to be gone over. The printer's reader and the author have again revises; and what they again correct is again attended to. The proof being now tolerably perfect, the labour of another reader is in most large establishments called in. It is his business to *read for press*—that is, to search for the minutest errors with a spirit of the most industrious criticism. The author has often to be consulted upon the queries of this captious personage, who ought to be as acute in discovering a blunder, as a conveyancer in finding out a flaw in a title-deed. But in spite of all this activity blunders *do* creep in; and the greatest mortification that an author can experience is the lot of almost every author,—namely, to take up his book, after the copies have gone out to the world, and find some absurdly obvious mistake, which glares upon him when he first opens the book, and which, in spite of his conviction that it was never there before, has become filled up with little globules of metal, they have to be cleaned or picked out; and if any impurities fill up the lines of a wood-cut, these likewise must be removed. The humble designation of a 'picker' scarcely does justice to the intelligent workman who undertakes this kind of labour; for taste and judgment, as well as accuracy of hand and eye, are called for in the due exercise of this vocation.

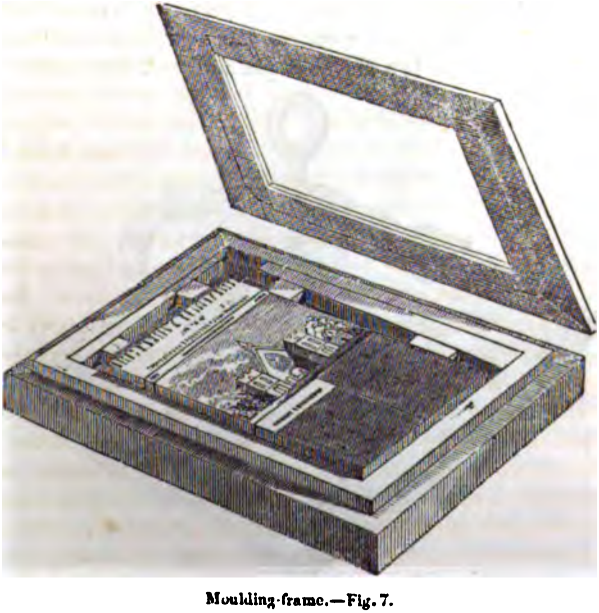
In the smaller of the two shops now under notice the *backs* of the plates are first ground or cut away to produce an uniform thickness of metal by the aid of a beautiful lathe; and the surface is then smoothed by a peculiar kind of plane.

We are now approaching that point where the types and the plates, prepared by this remarkable series of processes, are to be brought to bear upon the sheets of fair paper which are afterwards to form a book. We will therefore visit the paper warehouses. These portions of the establishment are loaded with piles of paper to an enormous extent; so large indeed, as to amount sometimes to five or six thousand reams! Right and left, from the floor to the ceiling, are these heaps deposited, ready to be removed when wanted for printing. In a brief but graphic account of this establishment, which appeared in the 'Quarterly Review' about three years ago, the following curious calculation was made, in reference to the contents of the paper-warehouses:—"The supply of white paper in store, kept in piles about 20 feet high, averages about 7000 reams; the amount of paper printed every week, and delivered for publication, is about 1500 reams (of 500 sheets), each of which averages in size 389⅜ square inches. The supply, therefore, of white paper kept in hand would, if laid down on a path of 22½ inches broad, extend 1230 miles; the quantity printed on both sides per week would form a path of the same breadth, 263 miles in length. In the course of a year Messrs. Clowes consume, therefore, white paper enough to make petticoats of the usual dimensions (10 demys per petticoat) for 350,000 ladies!"

As a convenience to hand down paper a large trap-door opens a communication between the paper warehouses and a 'wetting-room,' to which we will follow the paper in its march towards the printing-room. In the 'wetting-room' are tanks or cisterns, into which cold water is always flowing. A man or boy opens a ream of paper, and dips each quire a few times in water, regulating the degree of saturation to the circumstances of the case. From three to seven 'dips'

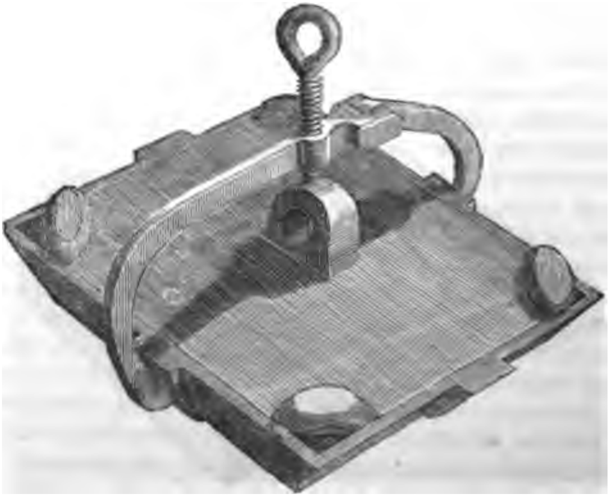
Understanding these few details, we now visit the stereotype foundry, a square room lighted by several skylights. Around the room are furnaces and ovens, a tank with a crane or tackle suspended above it, and various benches and apparatus occupied by men working either in plaster or in metal. We have said that a cast of the type is first taken in plaster of Paris, and that another cast is taken from this in metal; and the routine of proceedings is briefly as follows:—The first operation is that of taking a *mould* from each page of moveable types. The pages are not arranged as they would be combined in a sheet, and wedged up together in one iron frame or chase; but each page is put in a separate chase. It is essential that the face of the types should be perfectly clean and dry, and that no particle of dirt or other substance should attach to the bottom of the types, so as to prevent them being completely level upon the surface. The page is now placed upon the lower part of a *moulding-frame*, represented in Fig. 7, in which we have also depicted a wood-cut or block included as part of the page; for wood-cuts can be stereotyped as well as types.

The upper part of the frame is somewhat larger than the page, and



Moulding-frame.—Fig. 7.

the margin of mould thus formed determines the thickness of the plate. The types having been previously rubbed over with an oily composition, gypsum (plaster of Paris) is poured evenly over the whole surface. Almost every one knows that this substance, although moulded in a liquid state, sets very quickly, and soon becomes perfectly solid. There is a good deal of nicety required from the workman, not only in forming the mould, but in removing it from the type. If any part of the plaster adheres to the face of the type, the mould is of course imperfect, and the operation must be gone over again. To prevent this, considerable care is required in the preparation of the gypsum, and much neatness of hand in separating the mould from the page. Having been removed and found perfect, it requires some dressing with a knife on its edges, and several notches are cut in the margin to allow the metal to enter the mould. It is now fit for baking. This process also requires a good deal of accurate knowledge. The oven in which the moulds are placed upon their edges must be kept at a very regular temperature; for if it be too hot, the moulds warp. The process of casting begins when the moulds have been baked sufficiently long to be perfectly dry and hard. We next direct our notice to the *casting-box*, represented in Fig. 8. At the bottom of this box is a movable plate of cast-iron, called a *float-*



Casting-box.—Fig. 8.

ing-plate; and upon this plate, the face of which is perfectly accurate, the mould is placed with its face downwards. Upon the back of the mould rests the cover of the casting-box, the inside face of whose lid is also perfectly true. The cover is held tightly down in the mould by the metal screw and arm seen in the cut.

The moulding-frame being thus placed in the casting-box, the latter is immersed in an open copper or vessel, of which there are four in the foundry, each holding ten or eleven hundredweights of melted metal (antimony and lead). It will be seen that there are holes in the corners of the cover of the casting-box, through which the liquid metal finds its way into the hollow within. At the instant when the box is plunged into the metal, a bubbling noise is heard, which is occasioned by the expulsion of the air contained within the box. After having remained immersed for about ten minutes, it is steadily lifted out by the crane, and swung to a cooling trough, in which the under side of the box is exposed to water. Being completely cooled, the caster proceeds to remove the mould from the casting-box. The plaster mould, the plate moulded, and the floating-plate, are all solidly fixed together; and the metal, by its specific gravity, has forced itself under the latter, which it has consequently driven tightly up against the ledges of the mould. The mould has in the same way been driven tightly up against the lid of the casting-box; and the notches in the ledges of the mould have, at the same time, admitted the metal into the minutest impression from the face of the types. The caster now breaks off the superfluous metal and the ledges of the mould with a wooden mallet. The mould is of course destroyed; and if another plate is required, another mould must be taken from the types. After the superfluous metal and the plaster are removed, the stereotype plate comes out bright and well formed.

From the foundry we proceed to two busily-occupied shops, where the stereotype plates, produced in the manner just described, are finished off and prepared for the pressman. Sometimes letters of reference, explanatory of a wood-cut, are required; and these, if not inserted in the original block itself, are introduced in the plate. If any alterations, after all the corrections which the 'reader' has made, are still required, a portion of the plate is cut away, and types introduced into the cavity. Various adjustments of a similar kind are made, in which cutting, filing, melting, and soldering are the processes adopted. If the vacuities of such letters as the *a* and the *e* have become filled up with little globules of metal, they have to be cleaned or picked out; and if any impurities fill up the lines of a wood-cut, these likewise must be removed. The humble designation of a 'picker' scarcely does justice to the intelligent workman who undertakes this kind of labour; for taste and judgment, as well as accuracy of hand and eye, are called for in the due exercise of this vocation.

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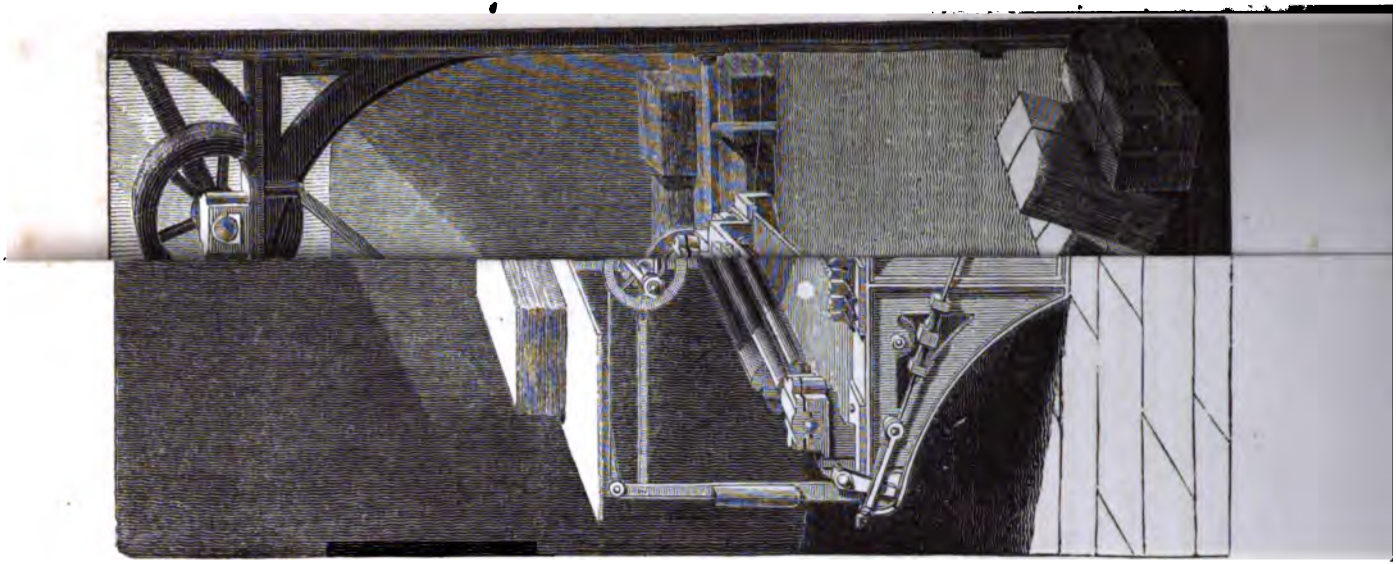
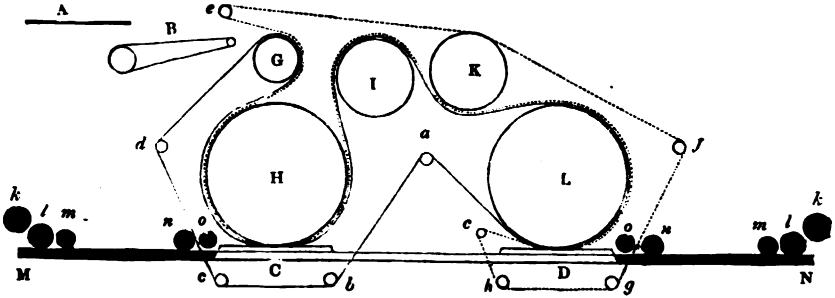
Now we arrive at the time when the bustling, the closely-filled, the all-important 'machine-rooms' are to be visited. Here we see around us four and twenty complicated printing-machines, working with untiring constancy from morning till night, giving forth at every few seconds printed sheets of paper. Adjacent to them, but in a separate building, are the two steam-engines, which supply motive-power to all these machines; while the steam-engines are, in their turn, fed with power from three large boilers in an adjoining apartment. Powerful and expeditious as are the performances of these steam-worked printing-machines, they form by no means the only printing apparatus in the place; for there are in this large establishment two dozen printing-presses, the distinction between which and printing-machines being, among others, that the former are worked by hand and the latter by steam-power. The rooms containing the presses are distinct from those which contain the machines, and a visitor cannot fail to remark the difference between the kind of labour required in one room and that required in the other. The inking of the types, and the working of a press, are operations requiring not only celerity of movement, but considerable muscular effort; whereas in the printing-machine steam does all the hard work,—in fact it effects everything except laying on the sheet of white paper, and removing the same sheet when printed. The printing-rooms, like most other parts of the factory, are so closely occupied, that some little care is required in threading one's way through and between the machines, presses, and benches; and if a visitor should bring away with him, on his garments, a few specimens of printing-ink, he must not be surprised.

It is not easy to understand the action of the large printing-machines, unless we first comprehend that of the more simple printing-presses. The presses employed by the early printers bore a tolerably close resemblance to a modern napkin-press; the 'form' or collected page of types being first inked, and then placed between the two boards of a screw-press.

It is evident that this mode of obtaining an impression must have been very laborious and very slow. As the screw must have come down upon the types with a dead pull,—that is, as the table upon

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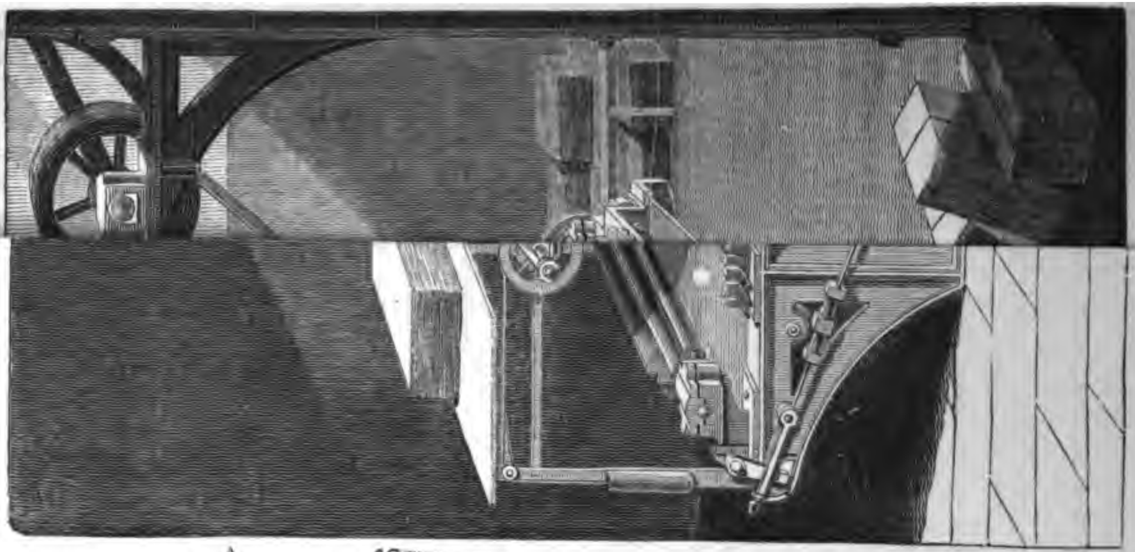
was highly difficult, if not impracticable, to the neglect of that portion of his plan which, since his time, has been brought into the most perfect operation. Nicholson's patent was never acted upon. The first maker of a printing-machine was Mr. Kœnig, a native of Saxony; and the first sheet of paper printed by cylinders and by steam was the 'Times' newspaper of the 28th November, 1814. The machine thus for the first time brought into action was that of Mr. Kœnig. Since that time various improvements have been introduced; and the machines now employed at this establishment, as well as many others, are those originally patented by Messrs. Applegath and Cowper, in which the double processes of inking and printing are effected by a beautiful system of machinery. To explain this action in writing is no easy matter; but in the annexed folding-cut we have given a representation of the whole machine, unencumbered by letters of reference; while adjacent to it is a diagram, representing a vertical section of the whole arrangement, which the letters of reference may enable us thus to describe:—

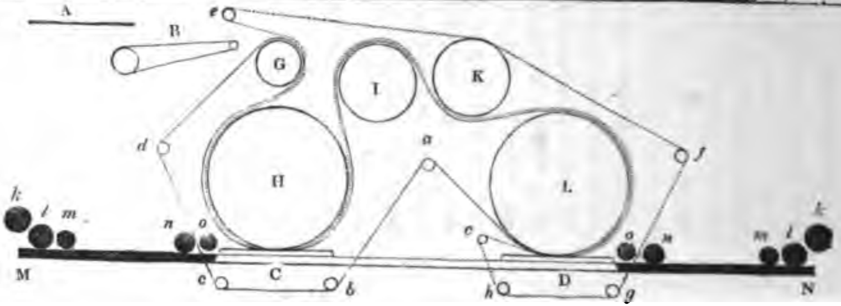
A sheet of paper, taken from the table A, is laid on the 'feeder' B, which consists of girths of linen, tightly stretched by being passed round two cylinders. By the motion of this feeder the sheet is placed between the two systems of tapes which lie on the cylinder G: these tapes, of which one set is represented by the dotted line, and the other by the thin line, lie two and two over each other on the cylinders and small rollers *a*, *b*, *c*, *d*, *e*, *f*, *g*, *h*, *i*. The sheet of paper grasped between them is kept clean at the places in which it is in contact with them, and by the motion of the various parts is conducted under the first printing-cylinder H, and receives an impression from the types at C: thence, by means of the cylinders I, K, to the second printing-cylinder L, where it receives an impression on the other side from the types at D. Thus printed on both sides, it is taken out at *e*, by an attendant. The cylinders I and K are simply for the purpose of conveying the sheet steadily and smoothly from one printing-cylinder to the other. The sheet will be seen to be reversed in its progress from one set of types to the other, descending the left side of the first, and the right side of the second printing-cylinder. An inking-apparatus is placed at each end of the table M, N, which carries the types C, D, and which traverses backwards and forwards under the printing-cylinders L, H, and inking-rollers. The ink, received from a reservoir *k*, tympan, and the frisket is folded down upon it; the 'form' of types is inked, and the tympan, with the paper and frisket attached, is folded over and brought down in contact with it, the frisket being so regulated as to allow the paper to come in contact with the inked type. The whole is then brought under the press, and the screw worked by hand; the pressure is relaxed; the 'form' drawn out; the tympan lifted up; the frisket opened; and the sheet of paper, printed on one side, removed.—All this takes a long time to describe; but the united processes do not occupy so much as one-fourth of a minute.

The Columbia press, the Albion press, and other modern varieties, have introduced sundry improvements; but they all act on the same general principles as the Stanhope, except that the force of the Columbia is applied by a lever, the Stanhope by a screw.

While watching the proceedings of the pressmen at such an establishment as this, we see that they apply ink to the surface of the type by means of an elastic kind of roller, formed of glue and treacle, the surface of which is coated with a slight layer of printing ink. But if we had visited a printing-office some years ago, we should probably have witnessed a mode of inking, as uncouth, perhaps, as can be conceived. Even at the present day, in humbler establishments, the 'inking-balls' are employed. These 'balls' are shaped somewhat like the colour-bladders used by artists, but are nearly as large as the printer's head. Holding one in each hand, he thumps them one against the other, against an ink-bed, and against the 'form' of type, with a sad waste of muscular strength. The printer used to have to make these inking-balls of sheep's pelt; and besides the time thus wasted, an enormous quantity of ink was also unprofitably expended.

Such was the state of the press department of printing, not only in England, but throughout the world, till the year 1814. As several approaches had been made before the time of Faust to the principle of printing books from moveable types, so the principle of producing impressions from a cylinder, and of inking the types by a roller, which are the great principles of the printing-machine, had been discovered in this country as early as the year 1790. In that year Mr. William Nicholson took out a patent for certain improvements in printing, the specification of which clearly shows that to him belongs the first suggestion of printing from cylinders. But this inventor, like many other ingenious men, was led astray by a part of his project which

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Let us begin with the first. Such a vast capital is lying dead, if the type for a book be kept in 'form' or undisturbed, that it is rarely done. One of the exceptions relates to certain parliamentary papers for which there may be a sudden demand, and which are kept in 'form.' Another exception is where the printer agrees with the publisher that he will keep the type of a new book in 'form' for a certain period, during which the publisher may be enabled to make a guess as to the probable sale of his book, and the cheapest way of supplying it. As such an arrangement as this is advantageous to the publisher, and entails a heavy stagnation of capital on the part of the printer, a stipulated price is paid for it. Some of the ware-rooms of the establishment are loaded with many tons of type kept in this undisturbed state.

In the next place, as to the stereotype-plates. When an edition of a work has been printed, the plates are all wrapped separately in paper (each page of the book having a distinct plate), and then stored away in a warehouse, properly marked and labelled. The stereotype warehouse affords a most striking example of the value which metal acquires when mental and mechanical ingenuity has been bestowed upon it. In this one apartment are collected stereotype plates whose estimated value is not much less than *half a million sterling!* And even the plates, valued as old metal, are estimated at seventy thousand pounds! The weight of metal is, perhaps, almost as astonishing as the value; for it is reckoned at two thousand five hundred tons; that is, between five and six millions of pounds avoirdupois! As an example of the mode in which this enormous accumulation is brought about, let us instance the 'Penny Magazine.' Eleven volumes of this work have tor' and carried off that supply,—and the distributing-rollers have spread it equally over the surface of the table. This surface having passed under the inking-rollers, communicates the supply to them; and they in turn impart it to the 'form' which is to be printed. All these beautiful operations are accomplished in the sixteenth part of a minute, by the travelling backward and forward of the carriage or table upon which the 'form' rests. Each roller revolves upon an axis which is fixed. At the moment when the 'form' at the back of the machine is passing under the inking-roller, the sheet, which the boy has carefully laid upon the table before him, is caught in the web-roller and conveyed to the endless bands or tapes which pass it over the first impression cylinder. It is here seized tightly by the bands, which fall between the pages and on the outer margin. The moment after the sheet is seized upon the first cylinder, the 'form' passes under that cylinder, and the paper being brought in contact with it receives an impression on one side. To give the impression on the other side, the sheet is to be turned over; and this is effected by the two drums in the centre of the machine. The endless tapes never lose their grasp of the sheet, although they allow it to be reversed. While the impression has been given by the first cylinder, the second 'form' of types at the other end of the table has been inked. The drums have conveyed the sheet during this inking upon the second cylinder; it is brought in contact with the types; and the operation is complete.

It is calculated not a little to astonish a visitor, to know that eight hundred sheets can be thus printed in an hour, even of works which require much care; while, by a modification of the machine, four thousand newspapers can be printed in the same space of time.

The printing-rooms, like the composing-rooms, have detained us a considerable time; but these are, in truth, the most important parts of the establishment. We will follow the printed sheets to another department, as a means of visiting another portion of the premises. When the printing of a number of sheets is completed, the paper requires drying before anything else is done with it; and this drying is effected in steam-heated rooms, provided with hundreds of cross-bars and poles, ranged in parallel lines. A boy, called the 'hanger-up,' is provided with an instrument called a *peel* (Fig. 12), and consisting of a broad flat piece of wood fixed to the end of a long handle. The edge of this peel is laid on a heap of damp printed sheets, and several of them, from two or three to eight or ten in number, are

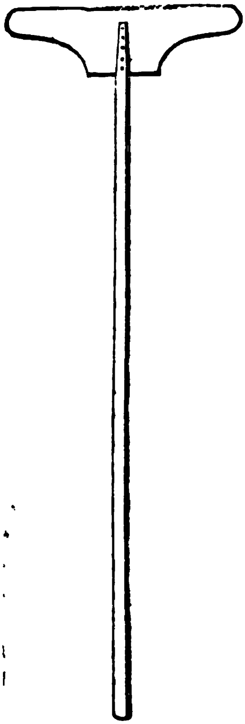
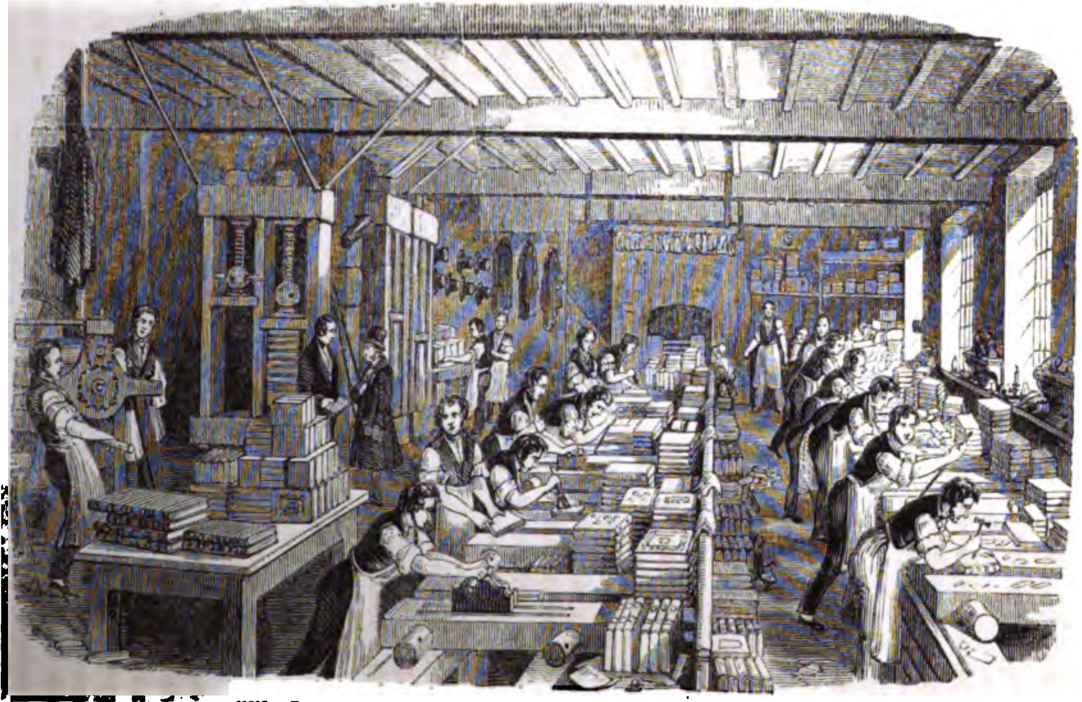


Fig. 12.

lapped over it. It is then moved sideways a few inches, and another portion is lapped over, till the peel is full; after which the whole are transferred to one of the drying poles. The rooms in which these sheets thus hang till dry are plentifully supplied with steam-pipes, by which any desired temperature may be maintained.

From the drying-room, the printed sheets are carried to another room, where, at an oblong bench beneath a range of windows, another boy called a 'gatherer' is employed. This boy is walking to and fro all day long, 'gathering' sheets of paper into certain heaps, an operation for the due understanding of which a little explanation is necessary. A book when printed consists of a certain number of sheets, and each sheet comes from the press or machine in one large heap. After the sheets are dried, and before the work is delivered to the binder, it is necessary to take a single sheet from each heap to form a perfect book; and to effect this is the work of the 'gatherer.' The heaps of sheets are ranged in order on a bench, in front of which the 'gatherer' walks, taking a sheet from each heap in succession, and holding the collected sheets in his left hand till he reaches the last heap, when the gathering is completed. The edges of the sheets of this gathering he makes quite even, and lays them down flat at the end of the bench. In the same room with the 'gatherer' is the 'collater,' who tests the accuracy of his proceedings. This collater sits before a gathered heap, and with a sharp bodkin lifts each sheet separately, to ascertain that they follow in regular succession, that none have been omitted, and that two of the same sheets have not been taken in mistake.

The collated sheets are, in most cases, folded into thicker heaps, called 'quires,' and subjected to the action of a very powerful hydraulic press, Fig. 13, which acts thus:—A pailful of water is put



XVI.—Roan-binding Shop.—Messrs. Westleys and Clark's Factory.—Face p. 363.

contained about five thousand six hundred pages, every one of which has had a stereotype plate cast for it alone; and there are now stored in the warehouse at Messrs. Clowes's all these five thousand six hundred plates, which, at 7 pounds weight each, amount to 39,200 pounds. The stereotype plates for the 'Penny Cyclopædia' amount to more than double of this in number and weight.

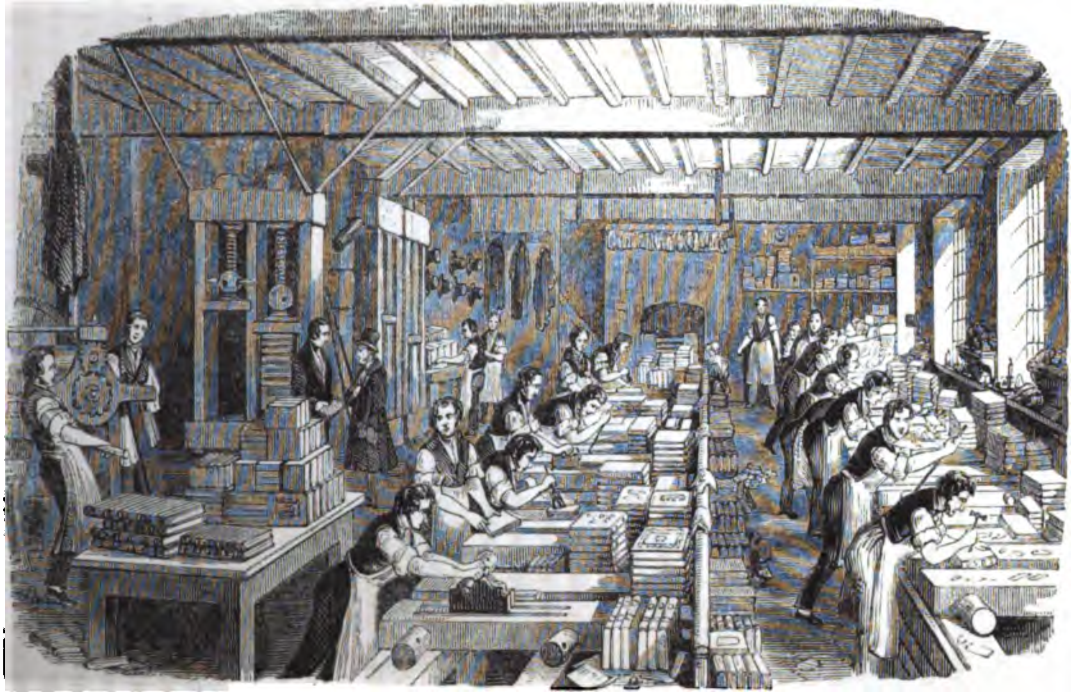
All these plates, belonging to numerous works which command a large sale, are ranged on shelves in presses or cases, the presses being built parallel, with avenues or passages between them, lighted by a few candles for the convenience of the warehouse-keeper. It is certainly a noiseless, an unobtrusive apartment, but it is one which makes a visitor marvel at the results which skill, enterprise, and capital have been able to obtain in the art of printing.

Another warehouse contains the wood-cuts, the blocks on which wood-engravings have been executed. Whether impressions be taken from the blocks themselves, or from stereotype plates cast from the blocks, the blocks are carefully preserved, classified, and labelled in a convenient manner. Another instance of stationary capital is here afforded. Eighty thousand blocks are deposited in the wood-cut warehouse, the average value of which is estimated at three pounds each—making an aggregate sum of nearly a quarter of a million sterling!

Finally, we come to that one of the three cases where, for each successive edition of a book (if more than one be required), the type has to be set up anew. This is the most usual system; and the wages of compositors are regulated by this method. Under this arrangement, directly all the copies of the work have been printed, the 'form' of types is washed in an alkaline solution, loosened, and the types 'distributed' again into their places. The compositor takes up a small heap at a time, and holding it in an ingenious manner in his left hand, drops the letters with his right, one by one, into the several cells of his 'case.' The accuracy and celerity with which this is effected are not the least astonishing among the operations of a printing-office; for a clever compositor can distribute fifty thousand letters per day into their respective cells. The mind and the fingers curiously assist one another in this operation; for the former has to follow the order of the letters in the words, and to select the cell into which each shall be dropped, while the latter have to separate one letter from another, taking care that only one letter is dropped at a time.

When a summer's day's labour in this large establishment is finished, a scene is presented which the writer before quoted thus depicts: it is true that "one o'clock" was the period to which he referred, but the picture is perhaps not less applicable to "leave-off time." "The extended arm of the distributer falls as by paralysis to his side—the compositor as suddenly lays down his stick—the corrector his bodkin—the impositor abandons his quoins, reglet, gutters, scale-board, chases, shooting-sticks, side-sticks, and his other 'furniture'—the wearied 'reader' slowly rises from his stool, his boy, like a young kid, having already bounded from his side. The wheels of the steam-presses abruptly cease to revolve—the 'doctor' even becomes motionless—the boys descend from the literary pinnacles on which they had been stationed—the hand-presses repose—and, almost before the paper-men, type-founders, and other workmen can manage to lay down their work, in both Duke-street and Stamford-street printers' boys of various colours are seen either scudding away in all directions, or assembled in knots to play at leap-frog, or at whatever other game may happen to be what is technically called 'in.' A fat, ruddy-faced boy, wearing a paper cap, is seen vaulting over the back of a young tight-made 'devil,' while a 'legion of foul fiends' appear gambolling in groups, or jumping over each other's shoulders."

Note.—The writer, in the preparation of this Chapter, has availed himself of information originally furnished under the title of 'The Commercial History of a Penny Magazine,'—a series of papers published in 1833, and written by the author of 'The Results of Machinery.'



XVI.—Roan-binding Shop.—Messrs. Westleys and Clark's Factory.—Face p. 363.

XVI.—A DAY AT A BOOKBINDER'S.

It is a necessary consequence of the connexion existing between different branches of manufacture, that no one of them can receive any notable increase or advancement without benefiting many of the others. Thus, the spur which was given ten or a dozen years ago to popular reading by the establishment of works issued at a small weekly price, and many of them illustrated by wood-engravings, has been the means of inducing changes and eliciting improvements in nearly all the arts connected with publishing:—wood-engraving, paper-making, printing, bookbinding—all have been affected by a moving-power which at first sight might appear a trivial one. Some of the works now published at a penny or three-halfpence weekly can vie with the costly works of bygone years in illustrations, paper, and printing; and those persons who were schoolboys in the days when schoolboys were whipped through 'Vyse's New London Spelling-book,' will not fail to see how rapidly such books are assuming the neat gilt-lettered cloth covers of modern times, in place of the nankeen 'roan' of past years.

The details relating to the large printing establishments of the present day will have prepared us to look for corresponding activity in the trade of *bookbinding;* and the factory of Messrs. Westleys and Clark, in relation both to mechanical and social economy, fully realises this expectation.

Any one who knows London intimately is aware that many of our large factories are so hemmed in on all sides by houses as to be scarcely visible externally. Such is the case with the building now under our notice. It is a large pile, built expressly for its present purpose, and presenting much the appearance of a cotton-factory; yet we can scarcely catch a glimpse of it till nearly close to its walls. To say that it is situated in 'Shoemaker Row' will not perhaps convey a very precise idea of its locality to the mass of readers; and we must therefore be content with saying that it has Ludgate Hill a little on the north, Doctors' Commons a little on the east, and Apothecaries' Hall a little on the west. The building is six stories or floors in height, and has an extensive range of windows from north to south, with an entrance in the middle. Into this entrance we will suppose the reader to accompany us.

Each floor of the building is in general appropriated to one class of operations, under the superintendence of a foreman, who is responsible for that department. A winding quadrangular staircase extends up the centre of the building from bottom to top, with landing-places, at which are several doors leading to the workshops. The basement story consists of many rooms occupied as warehouses, or for processes wherein heavy machines are employed. Thus, one room is the 'board warehouse,' where the mill-board, purchased from the stationer in sheets of various sizes and thickness, is deposited in classified recesses till wanted. Another is the 'cloth-warehouse,' where the cotton-cloth, now so extensively used for covering books, is kept and cut to sizes. Near this is the 'embossing warehouse,' filled with pieces of leather or cloth which have received some of those ornamental devices to be described hereafter. One room, which we will call the 'cloth-cylinder room,' contains two machines for imparting to cloth the diamond or granulated or speckled appearance usually presented by books in cloth boards,—an appearance which nearly hides the rectangular interlacings of the warp and weft threads. The 'embossing shops,' on the same range, contain three powerful machines for giving to the flat covers of books those beautiful devices which now so often distinguish them: if the book be a Bible, we have an emblematical device of a religious character; if it be a 'Shakspere,' we have something pertaining to the great dramatist; if it be a lady's album or portfolio, or letter-case or blotting-book, we have a device of a graceful and ornamental character. This is an approach towards what may perhaps be termed a 'principle' in bookbinding, viz., that the subject of a book may be known from its cover,—a principle which seems to have much to recommend it.

On ascending to the ground-floor, or that which is nearly on a level with the street, the hum of voices tells us that a numerous body of workpeople of both sexes are here employed. In the counting-house of the principals is one of those simple but valuable expedients for saving time, now so much employed in large factories,—we mean a series of 'speaking-tubes.' Tubes pass from this room to the counting-houses or offices of all the foremen above and below stairs, and with these are associated a range of bell-wires; a bell is first rung, which draws the attention of the foreman to his end of the tube; and a message being then whispered or spoken through the tube, he hears it readily, and gives the necessary reply. All the tubes are inscribed with the names of the department to which they belong.

The main portion of this floor is occupied by the 'boarding-shop,' a technical name for the shop wherein all the operations are conducted for binding books in cloth boards, the most prevalent style at the present day. In one part of this room females are engaged in folding the sheets, gathering them into groups, sewing them into the form of a book, &c.; while in other parts are men pursuing the subsequent operations of glueing, pasting, cutting, hammering, pressing, &c., by which the book is brought to a finished state. This is a very busy scene, and one presenting much variety, from the distinct nature of the processes carried on. In many branches of manufacture it is found convenient to locate the workmen according to the kind of labour required; but in bookbinding on a large scale it is found desirable to classify with respect rather to the style in which the book is to be bound, than to the nature of each individual process. Hence nearly all the workpeople required for binding an extensive order of books in boards are here congregated on one floor. The folding-tables for the folders, the sewing-frames for the sewers, and the various benches and presses for the workmen, are the scenes of many remarkable and ingenious processes, of which we shall speak more hereafter.

The next range (which, if we reckon the basement as the commencement, must be called the third) exhibits another example of the classification just alluded to. This is called the 'roan-shop,' or the 'sheep-shop,' in allusion to the preparation of those books which are covered with roan or sheep-leather. Most readers are perhaps aware that books bound in 'sheep' are less expensive than those bound in 'calf;' the leather itself is less costly, and the general style of workmanship less elegant. Hence workmen who are accustomed to one sort of binding are generally employed upon that kind; and hence the preparation of roan-bound books in a workshop different both from that above described, and from that devoted to more elegant work. This range is, however, not strictly confined to roan-bound books, since 'school-books,' whether bound in cloth or in leather, are prepared here. The large room exhibits nearly similar features to that below-stairs: females, in one department, are forwarding the earlier operations; and men, in another department, are finishing the volumes. Our frontispiece represents the appearance of this room.

Another room on the same range, known in the factory as the 'Pinnock' room, affords us a curious insight into the amount of sale which popular works sometimes command. This room is appropriated mainly to the sewing and covering of the little ninepenny books called 'Pinnock's Catechisms.' Of these small productions the sale is so large and so uninterrupted, that the processes of sewing and covering them proceed continuously. The numbers sold must be enormous; and indeed a glance through the operations of this range of the factory shows that such school-books as are so fortunate as to obtain a 'name' command an extent of sale scarcely equalled by any other kind of literary productions, with the exception of Bibles and Prayers. 'Goldsmith's England,' 'Mangnall's Questions,' 'Carpenter's Spelling,' and other school-books, were piled in such heaps and groups in various stages of preparation as to indicate pretty clearly the extent of the demand. What improvements these books may have received from time to time as literary productions, or may be susceptible of receiving hereafter, is no part of the present subject; but exteriorly they have marched with the march of the times, and have yielded to the bookbinding reforms of 'embossed-roan' and 'cloth-lettered.'

The fourth range of the factory is occupied by the 'extra' workmen; that is, those who are employed on the finer kinds of binding, such as Bibles and Prayers, gilt-edged books generally, and books exhibiting all the costly and elaborate varieties of 'Russia,' 'Morocco,' and 'calf' binding. One shop, called the 'extra-forwarding shop,' is occupied by the folders, pressers, sewers, &c., while the 'extra-finishing shop' sufficiently explains itself.

In the two upper floors of the factory are numerous rooms more or less subsidiary to those below-stairs. One or two are 'blocking-shops,' for lettering and ornamenting the covers of books; another is occupied by the men who make cloth-cases for books; in another the edges of books are gilt. One is the 'leather warehouse,' where all the various kinds of leather are kept, as procured from the leather-dresser, and cut to the required sizes. Another is the 'Annual' shop, in which the Annuals are bound at the particular period of the year when they are wanted. One of the rooms is termed the 'caoutchouc-shop,' as being devoted principally to those workmen who produce the caoutchouc or Indian-rubber binding; and there are a few others which are used or not, according as the amount of business fluctuates at different seasons.

Among several indications of a well-arranged factory, we noticed one which is always pleasing wherever observed. Many of the superintendents and workpeople appear to have been old standards, to have grown old with the growth of the factory, and to have shared with the proprietors the progress and fluctuation to which all manufactures are subject. This is a feature which we have more than once had occasion to notice in reference to large factories, and is one of considerable importance to the well-being of both the employers and the employed.

Having thus glanced at what we may term the factory-economy of the establishment, let us next endeavour to follow the routine of processes, so far as to acquire some idea how a book is built up after it leaves the hands of the printer. We shall for this purpose classify the various operations in three groups, according as they relate—1st, to *making-up* a book; 2nd, to *covering* a book; and 3rd, to *decorating* a book. A bookbinder would probably object to this mode of classification; but we think it will meet the wants of the reader better than a more technical mode of arrangement.

1st. *Making-up a book.* It must be obvious to all who reflect that a book is printed in large sheets, that these sheets must be separately folded and then connected together, before they can assume the form of a book. If we open, without cutting, a number of the 'Penny Magazine,' or of 'Chambers's Edinburgh Journal,' we see that the eight printed pages are so arranged as to follow in proper order when the sheet is folded in a certain manner; and if, as in the 'Mirror,' or 'Chambers's Information for the People,' there are sixteen pages in a number, the arrangement of these pages appears singularly confused when the opened sheet is inspected; but here, as in the former case, the pages are arranged solely with reference to the order of sequence when folded. Each sheet has at the bottom of the first page a letter, figure, or other symbol, called a 'signature,' intended to assist in arranging sheets properly in the volume.

The printer sends the sheets to the binder (we are speaking of bookbinding on a large scale) in large heaps or groups, arranged in one of two forms: either many copies of one sheet, or ten or twelve successive sheets of one volume, form the group: in the latter case the heap is called a *gathering*, or *quire;* but we will suppose the former to be the case, as it will enable us to speak of the *gatherers*. The heap of sheets passes to the hands of the *folders*, who are, we believe, almost invariably females. Each folder sits before a flat table or bench, on which she spreads out the sheets in succession. In her right hand she holds a small ivory or bone folding-knife, with which she flattens the foldings of the sheet. Every successive sheet of the group is folded in precisely the same way as that which preceded it, so that no particular skill is required in adapting the various sheets one to another; but the folding is nevertheless a process requiring much accuracy, especially in the finer kinds of binding, as the sheet is folded so as to make the top and bottom lines of the print range, without reference to the edge of the paper. The sheet is placed with the signature towards the left hand of the folder, on the under surface; and the foldings are more or less numerous according as the book is folio, quarto, octavo, 12mo, 16mo, 18mo, 24mo, 32mo, &c.—terms which relate to the number of printed pages in one sheet.

Supposing a group of signature A to be thus folded, another of signature B, and others, to the extent required for the volume, these will have to be 'gathered' into volumes at the next process. This gathering is simply breaking up the groups hitherto existing, and re-arranging the same sheets in the order necessary for the volume. Instead, for instance, of having twenty copies of one sheet, such as that with the signature A, one of A is taken, then one of B, then one of C, and so on, until there are as many groups as volumes, and each group containing the sheets for one volume. This 'gathering' is in most cases done by the printer before the sheets pass into the hands of the bookbinder.

The 'collater' now takes the group of sheets in hand and examines them to see that they occur in proper order, that no duplicates occur, that no sheet is wanting, that the folding is correct, &c. This is a process in which much expertness is shown. The group is bent at one corner, and the sheets allowed to spring back successively, leaving to the eye just sufficient time to catch the signature at the bottom of the first page of each. If these signatures occur regularly, according to the letters A, B, C, &c., or the figures 1, 2, 3, &c., or any prescribed combination of both, then the arrangement is correct; if not, any error is immediately adjusted.

When the book of loose sheets has been thus made up, the sheets are either at once sewed, or are previously beaten or pressed, according as the work is to be 'in boards' or 'bound.' It is well known that a bound book is more dense and compact than one in boards, and this difference is mainly due to the process immediately preceding the sewing. Until recent times the sheets were separated into small groups, called 'sections' or 'beatings,' and beaten with a heavy hammer till greatly compressed; but modern invention has marked out a much more effective mode of proceeding. The *rolling-press* is a machine in which two rollers, worked by hand, are made to rotate nearly in contact; a man places a small number of folded sheets between two tin-plates, and passes them between the rollers, on the other side of which they are received by a boy, who places the pressed sheets in heaps, and returns the tin-plates to the man. Independent of the saving of time and of muscular exertion, the rolling-press is found to be more efficacious than the hammer in producing less 'set-off,' or transference of ink from one page to another.

The sheets are placed for a short time in a standing-press, and are then again *collated*, to see that no disarrangement has occurred; any plates, too, which may be interspersed among the text, are now inserted. The *sewer* next sews the sheets to strings or bands at the back; but if the strings are to be rendered invisible, a *saw-mark* is made for the reception of each. The group of sheets is fixed tightly in a press, with the back edges uppermost, and a few shallow cuts are made with a saw, at right angles to the length of the book.

A *sewing-press* consists of a flat bed or board, from which rise two end-bars, connected at the top by a cross-bar. Three or more strings, according to the size of the book, are fastened by loops to the cross-bar, and are tightened down by a simple contrivance at the lower end. The sewer, seated somewhat obliquely in front of this machine, with her left arm passing round the left vertical bar (as seen in Fig. 2), proceeds to sew the various sheets to the bands, her left hand being behind the strings, and her right hand before. Each successive sheet is laid flat on the bed of the sewing-press, with the back edge in contact with the strings, then opened in the middle, and fastened to the strings by passing a threaded needle backwards and forwards through the central fold of the sheet; each thread, after passing from the inside to the out, being made to loop or twist round one of the strings before entering the sheet again. As soon as one sheet is fastened to all the strings, another is laid down on it, and fastened in a similar manner. A curious kind of stitch, called a 'kettle-stitch,' is made near the top is so far softened as to suffer the bands and the back edges of the sheets to yield to pressure; and this is followed by an operation which makes a stranger fear that the round of the back is destroyed for ever. The workman takes the book in his hand, front edge uppermost, and strikes the back forcibly against the bench; thus transforming the round back into a square back. Then, using some contrivances to keep the sheets in this position, he fixes the book in the cutting-press, and cuts the front edge in precisely the same way as the top and bottom; thus making all the edges perfectly square, and all the leaves perfectly equal in size. The most remarkable part of the operation then succeeds; for immediately on removing the temporary fastenings from the book, the whole of the leaves spring back to their former position, that is, convex at the back edge; and the slightest consideration of the nature of curvature will make it manifest that, as all the leaves are made perfectly equal in the cutting-press, a convexity at one edge must be accompanied by an equal concavity at the other. Hence is produced the hollow or 'gutter' of the front edge.

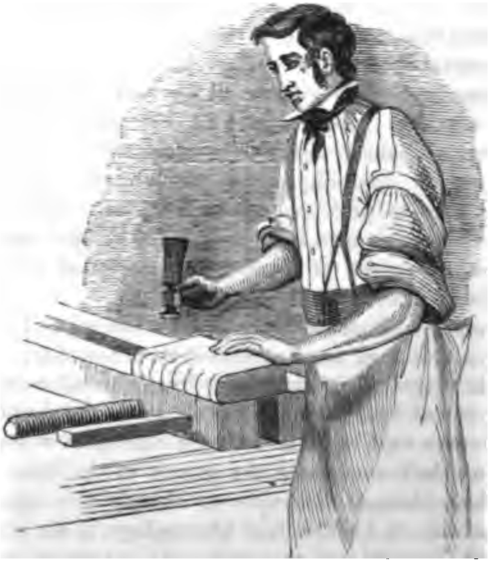
In this, as in other parts of bookbinding, the process is modified to suit different circumstances. Books in boards are either not cut at all at the edges, or are only partially cut; while bound books are carefully cut at top, bottom, and front edges.

We next turn our attention to the boards, which are permanently attached to the book in different stages of its progress towards completion, according to the nature of the binding. Millboard, the stiff substance of which the sides of books are formed, is a thick pasteboard composed of many parallel layers, glued or pasted together, and pressed in a mill to make them dense and smooth. The sheets are of various sizes and thicknesses, according to the size of the book for which they are required; and the bookbinder sometimes glues two together, to produce a board of double thickness. From the large sheets the smaller pieces are cut to form the sides of the books. In the first place, a pattern-piece, or size-pattern, is prepared, having the exact size and form of the boards to be cut. The cutting-machine is then adjusted to these dimensions, by causing an edged instrument, analogous to a scissor-blade, to work at a certain distance from a groove or raised ledge, against which the edge of the board is placed. The actual cutting is effected, as here represented, on the same principle as by a pair of shears; but the arrangement of the machine females in this country, that there are several departments of bookbinding within the scope of their ability. The greater part of that which has hitherto engaged our attention is intrusted to females; and in a large bookbinding establishment employment is thus afforded to a considerable number. This firm, for instance, in a busy season, give employment to about two hundred females, whose weekly earnings average from ten to eighteen shillings; and where a supervision, at once kind and judicious, is observed by the principals, an honourable subsistence is thus afforded for those who might have no other resources to fly to.

While speaking of making-up a book, we must remark that caoutchouc or India-rubber binding requires no sewing. The sheet is cut into separate leaves, and these leaves are retained solely by a cement of caoutchouc applied to their hinder edges. The leaves are allowed to assume a round contour at the back-edge by placing them in a kind of mould or gauge, shaped for the purpose; they are then rasped, to give a slight roughness for retaining the caoutchouc afterwards applied. A flexibility is produced by this kind of binding, greater than can be presented by a sewed book; while at the same time the caoutchouc cement is so retentive as to bind every single leaf firmly. This new mode of binding was introduced a few years ago, and is valuable for many kinds of volumes.

2nd. *Covering a Book.*—We have now made up the sheets into the form of a book, and have connected them together. Whether the volume is in elegant 'calf-extra,' or 'Russia-extra,' or whether it is a roan-bound school-book, or a 'boarded' book, the sheets are brought together in some such mode as we have attempted to describe above. Here then we shall commence the second of the three sections into which we have thought it proper to classify the operations. The 'cover' of a book, in bookbinders' phraseology, is the piece of leather or of cloth which envelopes the millboard; but the reader of a book, when he speaks of its cover, gives the term a much more extensive application. We must therefore at once explain that the leather or cloth is called technically the *cover*, the stiffening substance within is the *board*, and both taken collectively the *case*.

When the book is taken from the sewing-press, an inch or two of each string is left hanging to it: these are afterwards either scraped so thin as to be but little conspicuous, or are employed for fastening the book to its case. The back of the book—that is, the assembled back-edges of all the sheets—is glued, to increase the bond by which they are held together. When the book has gone through one or two other minor processes, that one succeeds which is perhaps as remarkable as anything displayed in bookbinding; viz. rounding the back and hollowing the front. Most persons can understand the production of a square back and edge to a book; but the graceful convexity of the one and concavity of the other, in most books bound in the modern style, are as curious in the mode of production as they are pleasing in appearance. In the process of 'backing,' by which this effect is produced, the book is laid on a bench, held or pressed by the left hand of the workman, as shown in Fig. 3, and hammered near the back edge, with such a peculiar movement of the left hand as causes the back to become rounded while the hammering proceeds. The effect is so instantaneous that a looker-on scarcely knows how or when it is produced. The state of the back is such as to enable the sheets to yield to the rounding action of the hammer, being coated with glue not yet dried; and the subsequent drying of the glue retains the sheets permanently in the position which they thus acquire.



Rounding the Back of a Book.—Fig. 3.

It may perhaps have occurred to many a reader, that as the board of a book is frequently of considerable thickness, it is likely to project beyond the back and to form a stiff and inconvenient hinge. This is prevented by a very simple contrivance, adopted at the time when the book is 'backed.' It is placed between two pieces of plank called 'backing-boards,' the hinder edges of which are placed precisely where the two hinges of the book are to come. The book, with the boards thus placed, is then squeezed tightly in a press, with the back edge uppermost; and the back being thus again hammered in a round form, a portion of edge projects over the boards, so as to form a kind of groove into which the millboard may afterwards conveniently be adjusted.

The reader will bear in mind that the edges of the book are all this time rough and uneven; but the time has now come when these edges must be brought to the level and smooth surface which adds so much to the beauty of a book. There are a few minor processes carried on about this time; but the plan of our article requires that we should notice only those of more prominent importance. In former times the edges were cut in a most clumsy and rude manner by means of shears, one blade being fixed to a bench, and the other being moved by the right hand of the workman, while his left hand held the book: thus the leaves were cut a few at a time. The cutting of the edges was partly effected by this method, and partly by drawing the edge of a sharp knife along the leaves, guided by the edge of a board. The 'cutting-press' of the present day is, however, a much more effective arrangement. The book, after being properly adjusted between two boards, is screwed in a press, with one of the ends projecting a little above the level of the bench. The ends of all the leaves are then cut off while in this position, by means of an instrument called a 'plough,' the cutting edge of which, in its mode of action, is midway between that of a pointed knife and a plane-iron. The edges are all cut to a perfect level; and the book being reversed, the other end is similarly treated. But by far the most remarkable part of the process is that by which the concave front edge is brought to such a regular curve. Most persons who have thought of the matter at all may have conceived that this concavity is produced by scooping out a portion with a gouge; and indeed the circumstance of the concavity of the front edge being just the same in degree as the convexity of the back has given rise to many sage conjectures wholly wide of the truth. The glue with which the back of the book had previously been coated is so far softened as to suffer the bands and the back edges of the sheets to yield to pressure; and this is followed by an operation which makes a stranger fear that the round of the back is destroyed for ever. The workman takes the book in his hand, front edge uppermost, and strikes the back forcibly against the bench; thus transforming the round back into a square back. Then, using some contrivances to keep the sheets in this position, he fixes the book in the cutting-press, and cuts the front edge in precisely the same way as the top and bottom; thus making all the edges perfectly square, and all the leaves perfectly equal in size. The most remarkable part of the operation then succeeds; for immediately on removing the temporary fastenings from the book, the whole of the leaves spring back to their former position, that is, convex at the back edge; and the slightest consideration of the nature of curvature will make it manifest that, as all the leaves are made perfectly equal in the cutting-press, a convexity at one edge must be accompanied by an equal concavity at the other. Hence is produced the hollow or 'gutter' of the front edge.

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The covers of books are decorated in a greater variety of ways than the edges. Roan-bound school-books are sometimes 'marbled' outside; a process which bears some resemblance to the sprinkling of the edges. A liquid composition of copperas, potash, water, and any common colouring substance, such as umber, is made. The books are opened, and hung over two bars, so that the boards may be nearly horizontal, and the leaves hang vertically downwards. The liquid colour is then dashed on somewhat in the way before explained, so as to cover the back and sides of the book; the spots or splashes being larger or smaller, according to the mode in which the brush is handled.

A mode of improving the appearance of Morocco leather for the covers of books is not a little striking. Whoever compares the appearance of a piece of Morocco in a slipper or a chair-cover with that presented by a well-bound book will perceive that the former has a wide apart to allow for the thickness of the book; and the case, thus made, is attached to the book by the back of the book being covered with stout linen and afterwards fastened to the case: the end-papers are then glued to the boards.

In a bound book, however, the process is different, and more carefully conducted. The boards being adjusted to the proper sizes, the back of the book rounded, the edges cut, holes made through the boards opposite to the strings, and the strings of the proper length, the boards are fastened to the book by passing the ends of the strings through the holes and pasting them down. The 'hollowness' in the backs of some books depends on a cause independent of the fastening of the bands or strings. If we open a 'hollow-backed' book, we shall see that the leather or cloth cover springs away from the back edge of the sheets; whereas other books appear to have the leather firmly attached thereto. This difference arises simply from the interposition of a doubled layer of paper or cloth between the leather and the back of the sheets: this layer helps to strengthen the book, and, at the same time, admits of the back being made close or hollow, according as the two layers of paper are or are not made to adhere together. If we suppose a hollow cylinder of paper to be pressed flat, and one side pasted to the back edge of the sheets, while the leather cover is pasted to the other side, we shall have some idea of the nature of a 'hollow back.'

When a book, attached to its boards by means of the bands, is ready to receive the leather covering, the leather is cut to the required size, allowing about half an inch all round for paring and turning in. The edge is pared or cut away obliquely with a keen knife, to prevent the unseemly projection which would otherwise result. If it is to receive any of those decorations which add so much to the external beauty of a book, the imprinting of the devices is done partly before and partly after the leather is attached to the book, as we shall explain farther on. But the mode of pasting the cover on the book is the same in both cases. The leather is laid smooth with the face downwards, and the back surface well coated with paste. The workman then takes the book in his hands, lays the back evenly in the middle of the leather, and draws and smooths and works the latter until it adheres closely to the back and boards of the book. This is a process of very great nicety; for not only must the more obvious parts of the surface be closely covered, but the overlapping edges, the turning-in, the corners, &c., must all be finished with great exactness, or the book will be at once spoiled. It is one of those operations so frequent in manufactures, wherein success depends on a nicety of manipulation, as incapable of being described as of being imitated without long practice.

There is one little appendage which we may notice here, viz. the *head-band*. Every one is familiar with the fact that his Bible has a little band or edging of silk at the top edge, where the paper joins the covers. This head-band is partly for service and partly for appearance: it helps to sustain the leather at the back of the book at the same level as the boards; and it gives a neat finish where slight imperfections might be otherwise visible. The better kinds of head-bands are formed of little strips of vellum or pasteboard, with coloured silk twisted over and around them in the process of fixing them to the book; while the commoner kinds consist of a cord inserted in a doubled piece of coloured silk or cotton cloth. We may also here mention the 'raised bands' which are sometimes used for ornament in the better kinds of books: they consist of little strips of leather or cord pasted across the back of the book before it is covered, and afterwards stamped and gilt so as to contribute to the beauty of the volume.

3rd. *Decorating a Book.*—We have glanced through the more prominent operations by which the book is made to assume its compact, convenient, and durable form; omitting mention of many slighter manipulations which would neither suit our limits nor be intelligible to general readers. There is, however, a wide difference between a book thus prepared and the same book as given in a finished state from the hands of the bookbinder. The edges of the leaves are cut; but they are white, neither coloured nor gilt: the boards are covered with cloth or with leather; but neither cloth nor leather is embossed or stamped, or gilt or lettered. As these adornments are subsidiary to the formation of the book itself, we have thought it better to group them by themselves, whether they are done before or after the cover is laid on the book.

First, then, for the edges. The majority of cut-edged books are treated in one of two ways—*sprinkled* or *gilt;* the first being the most general method for bound books, and the second for Bibles, Prayer-books, Annuals, and the higher class of bound books. The sprinkling is a singular process, and one which differs greatly from the idea which many may have formed of the matter. The edges of the majority of bound books present a speckled appearance, arising from a coloured liquid or paint being laid irregularly over them; and the peculiarity consists in the mode of producing the small spots. The colour is laid on, not with a brush, as in painting, but by the following contrivance:—A set of books, to be sprinkled of one colour, are ranged side by side on a bench, in a recess shielded from other parts of the factory. A colour is mixed up, of umber, Venetian red, or any other cheap pigment, with water and paste or size; into this the workman dips a large brush, and then strikes the handle or root of the brush against a stick held in the other hand at a height of two or three feet above the books: the action is so governed as to cause a shower of spots to fall on the edges of the books; which spots are not so thickly congregated as to cover the whole surface, and are yet such as to have an equable appearance when finished. The mode of handling the brush is obviously the point on which the success of the process hinges. Some books have the edges *marbled* instead of *sprinkled*: this is done in a manner similar to that observed in making *marbled paper*, and is the work of a separate class of men.

The operation of *gilding* the edges of books is one which illustrates in a striking manner the dense and compact form into which the leaves of a book are brought by pressing and binding. The edge of a well-bound Bible presents a fine, smooth, glossy, and brilliant surface, so equable and uniform as to render the distinct leaves almost invisible; yet these leaves can be parted as easily as if their edges were not gilt, and each edge presents its fine and delicately-marked line of gold. Were not the leaves pressed together as compactly as a mass of wood, this effect could not be produced.

There is in the process of gilding edges, as well as that of cutting them, a necessity that the front and back of the book should be brought perfectly square before the operation. The leaf-gold could not be bent into the curvature of the 'gutter' if this were not temporarily made flat: the book is therefore brought to the required form (while the case or cover is yet in an unfinished state), held tightly in a press, and the edges scraped smooth with a straight-edged piece of steel, to remove all asperities left by the cutting-plough. The edge is then coated with a liquid composition of red chalk and water; and, while this is setting or partially drying, the gilding-tools are being prepared. The leaf-gold is blown out from the book in which it is sold by the goldbeater, upon a cushion covered with leather, where it is placed out smooth by the aid of a knife. Each leaf is then cut up into two or more pieces, according to the size and thickness of the book whose edge is to be gilt. On the work-bench is a cup containing white of egg beaten up with water, a little of which is laid, by means of a camel-hair pencil, on the still damp surface of chalk and water. The gold is then taken up, piece after piece, by a flat camel-hair brush, and laid on the book-edge. This is done to all the three edges in succession; the book being turned round in the press to bring the successive edges uppermost. After the lapse of a very few minutes the gold has become sufficiently dry and set for polishing, a process which would seem calculated rather to rub off every atom of gold than to polish it. The workman holds in his two hands a long-handled burnisher, at the lower end of which is fixed a very smooth straight-edged piece of hard stone: this he places on the gilt surface, and with his left elbow resting on the workbench, and the handle of the burnisher resting on his right shoulder, he rubs the gold with great force at right angles to the direction of the leaves. No gold is rubbed off, but the whole is brought to a high degree of polish; the compactness of the leaves being such as to allow no chalk-colour or egg or gold to penetrate between them. If the burnisher were worked in the direction of the leaves, the polish would not be so high. The boards of the book are during these processes turned back as far as possible; and when the gilding is completed, paper is wrapped round the gilt edges to prevent the gold from being soiled in the subsequent finishing of the book.

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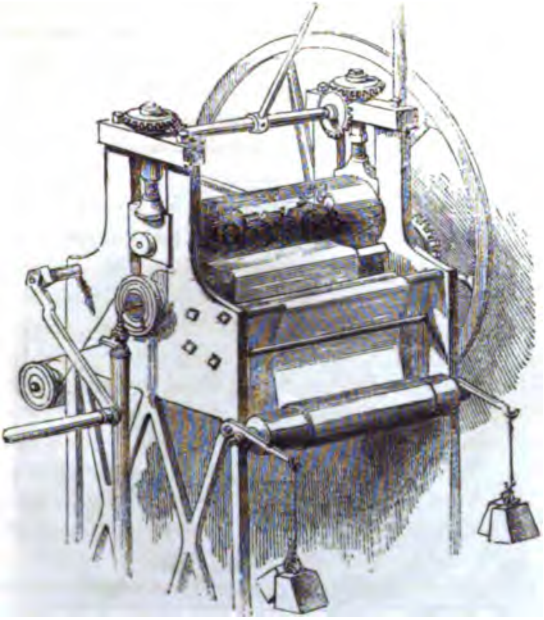
A mode of improving the appearance of Morocco leather for the covers of books is not a little striking. Whoever compares the appearance of a piece of Morocco in a slipper or a chair-cover with that presented by a well-bound book will perceive that the former has a series of irregular lines or grooves; whereas the latter has a regular granulated appearance. In our notice of the Leather Manufacture, we explain how the wrinkled appearance of Morocco leather is produced; and may here describe the simple contrivance whereby these same wrinkles are removed. The leather is first wetted and laid on a bench. The workman fastens to the palm of his right hand, by means of a strap passing over the hand, a large flat piece of cork. Then, doubling one portion of the leather over another, so as to bring two surfaces into contact, he gently rubs the upper fold of leather to and fro with the piece of cork; varying the extent and position of the doubling, and the direction of rubbing, so as to let every part of the surface be rubbed against some other part. The effect is very marked; for not only are all the wrinkles removed, but they are replaced by a kind of granulated surface, consisting of a uniform series of minute raised spots. When the leather has been allowed to dry, it retains this texture permanently, and is then applied to the covering of books.

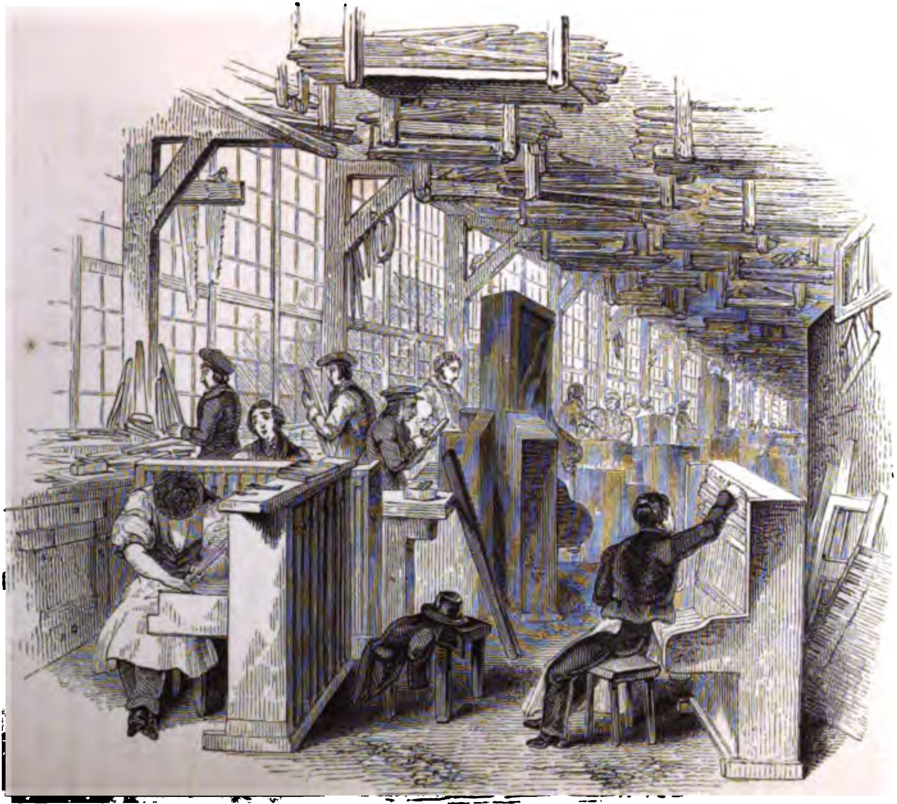
The cotton-cloth with which so large a number of new books are now covered has an ornamental character given to it in three different ways, either before or after it is applied to the boards of the book. One of these is the imprinting, all over the cloth, of a small and uniform pattern calculated to hide the barrenness and stiff uniformity of the threads in the cloth. If the reader has an opportunity of inspecting the backs of many cloth-bound books, he will see that there are a great variety of patterns thus given to the cloth. The process is as follows:—In the basement story of the factory which has been engaging our attention, are two machines for preparing the cloth, each of which consists of two cylinders rotating in contact by means of the usual machinery, as represented in Fig. 5. The cylinders are engraved with the device which is to be impressed on the cloth, and there are therefore as many pairs of cylinders as there are devices, each pair being fixed to the machine as wanted. By a very ingenious contrivance, a row of small jets of gas is carried through the interior of the lower cylinder, by which it becomes heated throughout. Every kind of stamping or embossing in leather or cloth is more effectively performed when aided by heat, and it is to afford this heat that the gas-jets are employed. The second machine, on the same principle, is to impress particular designs, of which a large quantity may be required. The piece of cotton-cloth, many yards in length, is inserted between the cylinders by its extreme end, and is then, by the action



Cloth-embossing Machine.—Fig. 5.

of the machine, drawn regularly between them, receiving its impress as it passes.

The embossing-presses act on a different principle. The device is in this case engraved on a flat thick plate of steel or gun-metal, which is stamped down upon the leather or cloth. We have stated that there are three embossing-presses situated in the basement of the factory. These are of immense power; indeed one of them exerts a pressure of no less than *eighty tons*. The mode of using is simply thus:—The cover or the case for a book is laid flat on a tablet or bed heated with gas from beneath, or else on a counter-die similar to that by which it is to be impressed. The engraved plate (which is in 'intaglio,' like a seal, but not so deep) is fixed to the press with its face downwards, and by manual labour, exerted on very powerful levers, it is brought down upon the cover with such force as to impart its device to the leather or cloth, the device being of course raised, or in relief, like a 'cameo.' There are some instances in which the embossing is



XVII.—Interior of Messrs. Broadwood's Factory.—Face p. 387.

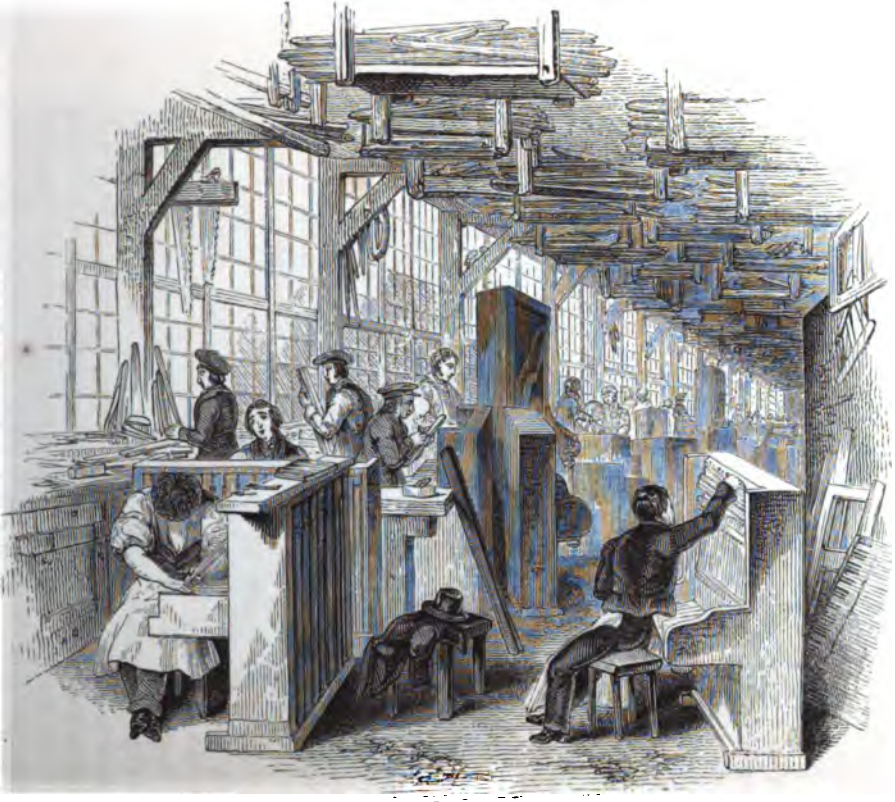
with gold, in which case it is called 'blind-tooling:' in others, gold is laid on the book, and then stamped down with the heated tool. The workman has a vast number of tools, such as rounds, squares, points, scrolls, diamonds, lines, letters, &c., the combination of which, according to the taste which he is enabled to display, produces a pattern. The book is laid on a bench, with its back or sides uppermost, according to the part under operation, and the workman presses the heated tools down on the level surface, leaving a device which is at once depressed and polished. In large or elaborate devices he has a paper pattern for his guidance.

When the device is to be a gilt one, the leather requires certain preparatory processes to fit it to retain the gold. It is coated first with size, then two or three times with white of egg, and lastly slightly touched with a piece of oiled cotton at the time the gold is laid on. The gold is laid on in slips of greater or lesser size according to the pattern; and the heated tools are immediately impressed on it, whereby the gold is made to adhere permanently to the leather. The loose or superfluous gold is then wiped off with a rag—which rag, we may remark, becomes an article of no small value in the course of time.

All that we have here said of ornamental devices applies equally to the lettering of a book. Where, however, it may be done conveniently, the punches or small devices, instead of being fixed in handles and used singly, are fixed, by means of glue and cloth, to a metallic plate, and thus impressed on the book at one blow by a press. This is then called 'blocking.' In the 'blocking-shop' are drawers and boxes filled with various small devices in brass, which the workman combines according to his taste, and fixes to a flat block or plate. The plate is attached to the upper bed of a press, heated by means of gas within; and the case of the book being introduced beneath, the block is let down on it, and imprints the device, whether it be gilt or 'blind.' Where a fillet, or line, or running sprig forms part of the ornament on the back, sides, or edge of a book, it is frequently done by a wheel or 'roll' in the manner presented in Fig. 7. The edge or periphery of the wheel has the device in relief, and this, being wheeled along carefully over the surface of the book, leaves a corresponding depression.

Such are the principal modes by which a book is decorated. We have been able merely to give a type or general representation of each, end with a little brass wedge that struck the string when the front end of the key was pressed down. To improve the tone elicited from the string the brass wedge was superseded by a quill, and the instrument then acquired the names of the *virginal* and the *spinet*. As a still further improvement, it was proposed to have two strings to every note, so as to increase the volume of sound: this involved a considerable increase in the complexity of the mechanism, and the improved instrument, under the name of the *harpsichord*, was in high repute during the greater part of the last century. At length occurred the happy thought of dispensing with the quills, and using little wooden hammers covered with leather, as a means of eliciting the tones of the strings, a modification which gave rise to the modern *pianoforte*, so named, probably (although rather clumsily) from the power of the instrument in producing "piano" and "forte," or soft and loud effects.

It has been said, in a recent article in the 'Westminster Review'—"With a little allowable flattery of the truth, the bookcase, in an inventory of the goods belonging to any well-ordered English house, might be designated as one of its necessary articles of furniture—not as one of its luxuries; the place of popularity among the latter being claimed by the pianoforte." Whether we rank it as an article of furniture or as a luxury, it is certain that the use of the pianoforte has become diffused in an extraordinary degree in this country. Those who can carry their recollection back over a period of thirty or forty years will remember the pianoforte as an instrument for the noble and the wealthy, sparingly seen in the houses of the middle classes; they will remember the gradual steps by which it has reached the domestic firesides of the bulk of the class just alluded to; and they will be prepared to expect that such an extension in the use must have brought along with it extensive plans of improvement, and equally extensive manufacturing arrangements: yet there are probably few, even of those who are familiar with the use of the pianoforte, who are aware of the complex mechanism of the modern instruments, or of the gigantic scale on which the manufacture is conducted. On these points we shall endeavour to offer a few words of information, which we are enabled to do by the courtesy of Messrs. Broadwood, the eminent manufacturers. This firm, which has existed in the metropolis for more than a century, is one of those by whom the pianoforte has been brought to its present state of perfection. Like most other products of ingenuity, this instrument is indebted to many minds for its ad-



XVII.—Interior of Messrs. Broadwood's Factory.—Face p. 387.

XVII.—A DAY AT A PIANOFORTE FACTORY.

A HUNDRED and twenty years ago, Dr. Arne, then a stripling, who, like many other striplings, loved music much better than the study of the law, used to delight in practising by stealth after the family had retired to rest. He had in his bed-room an old *spinet*, from which, after muffling the strings to deaden the sound, he drew such tones as it could afford, and which have been described as "weak, wiry tones, between a cough and a chirp, elicited by keys rattling like the dry bones of a skeleton."

If Arne, or any one who, like Arne, had been accustomed to the clavichords, the virginals, the spinets, and the harpsichords of past ages, could see a pianoforte of modern times, how great would be the change perceived! All these instruments, together with the psaltery or dulcimer, act on the same principle—a principle which marks a separation between them and the violin on the one part, and the lute, the harp, and the guitar, on the other. This principle is the striking of a stretched cord, to produce from it the tone due to its length, thickness, and tension; yet, though fundamentally the same, how different in effect are these several instruments! The modes in which the principle is modified in the several forms of instrument are curious, and may thus be briefly glanced at. The ancient *psaltery* (nearly the same instrument as the modern *dulcimer* occasionally seen in our streets) was probably the original whence all the others have emanated; and, according to Mr. Hogarth, "consisted of a square box of small depth, over which was placed a sounding-board of fir, and on this sounding-board were stretched a set of strings of steel and brass, tuned to the notes of the scale." They were struck or played upon by two little rods held in the hands of the player. A great change was effected when the little rods were abandoned, and mechanism introduced whereby each string was provided with a lever which struck it. The lever constitutes the key of such instruments as this, and, in the form of instrument called the *clavichord*, was provided at the hinder end with a little brass wedge that struck the string when the front end of the key was pressed down. To improve the tone elicited from the string the brass wedge was superseded by a quill, and the instrument then acquired the names of the *virginal* and the *spinet*. As a still further improvement, it was proposed to have two strings to every note, so as to increase the volume of sound: this involved a considerable increase in the complexity of the mechanism, and the improved instrument, under the name of the *harpsichord*, was in high repute during the greater part of the last century. At length occurred the happy thought of dispensing with the quills, and using little wooden hammers covered with leather, as a means of eliciting the tones of the strings, a modification which gave rise to the modern *pianoforte*, so named, probably (although rather clumsily) from the power of the instrument in producing "piano" and "forte," or soft and loud effects.

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Messrs. Broadwood's principal factory is situated in the Horseferry Road, Westminster, in the immediate vicinity of two other establishments noticed in this volume, viz., the "London Marble Works," and the "Westminster Gas Works." Whoever might conjecture that a pianoforte factory was merely a large workshop in the rear of the ware-room in which the finished instruments are sold, would be somewhat astonished at visiting the one to which we allude. In the Horseferry Road are two double gates, opening into courts or quadrangles; and in Holywell Street, three hundred feet southward of it, are two other gates, also opening immediately into the same quadrangles; and the whole of the intermediate space, spreading to a wide extent east and west, is occupied by the factory. On entering one of the gates, we find before us a long open court, occupied principally by piles and tiers and logs of wood, and bounded on either side by ranges of workshops extending three hundred feet in length. Advancing half-way along the court, we find, on either side, an archway, leading beneath the buildings to other courts or open quadrangles, one to the east and one to the west of that by which we enter: these quadrangles, like the first, are bounded on both sides by long and uniform ranges of workshops. We are then enabled to see the extent and form of the factory. It consists of four parallel ranges of buildings, every range lighted by windows on both sides, and having in general three tiers or stories of workshops in height.

The four ranges are separated by the three court-yards, and at the ends are four or five dwelling-houses inhabited by the superintendents and foremen of the establishment. Each range is wide enough to have in most parts two workshops in width; and as most of the ranges are three stories in height, there is an aggregate length of workshop truly enormous; in fact it considerably exceeds *half a mile* —an extent to which there are probably very few parallel instances in the metropolis.

In these four ranges of buildings three or four hundred men are engaged on the various component parts of pianofortes, from the first sawing of the rough timber, to the polishing and regulating of the finished instruments. Besides these there are many others engaged in the smaller branches of the manufacture, who do not work on the timber; and at one end of the west central range is a series of about ten or a dozen sawpits, where the logs are cut into planks.

It would be no easy task, nor indeed would it be necessary, to describe the arrangements of the various departments of workshops. It may suffice to say that they bear some resemblance to the shops of a cabinet-maker, in relation to the materials and the tools employed. The work-benches, about three hundred in number, are placed in general transversely, with one end towards the windows; and on the side opposite to the windows are the stoves and fire-places for warming glue, and other operations in which heat is required. Overhead, in nearly all the shops, are piles of wood in various stages of preparation for the use of the workmen, and undergoing the last process of seasoning by the warm temperature of the shops. A better idea of the nature of the several employments may perhaps be gathered by tracing, in a cursory way, the progress of a pianoforte in its several stages of manufacture.

Whatever form or value the pianoforte may have, it consists of a case containing stretched wires, which wires are struck by soft hammers, attached to the hindmost end of the finger-keys. This being the general character of the instrument, the various subdivisions are as follows. It was stated in a former paragraph that the *harpsichord* was an improvement on previous instruments, by having two strings to every note: this improvement has been retained in the pianoforte, together with the later one of having soft hammers instead of quills. The "tinkling grandfather of the pianoforte," as the *clavichord* has been called, had but four or five octaves; the harpsichord five or five and a half; but the pianoforte has extended its range to six and a half. These points being remembered, then, we may state, 1st. That the *square* pianoforte has the strings horizontal, in a rectangular case, with two strings to each note, and a compass varying from five and a half to six and a half octaves. 2nd. The *cottage* pianoforte has its strings arranged vertically, reaching nearly from the ground to a short distance above the level of the keys; the case is much shorter than in the square; there are two strings to each note; and the compass is generally six octaves. 3rd. The *cabinet* pianoforte is much higher than any other, except the *upright grand*, a form not now manufactured; the strings, two to each note, are ranged vertically, but, unlike those in the *cottage* form, are elevated wholly above the level of the keys; in general the compass is six octaves, but the most finished instruments have a maker shapes the various pieces of wood by moulds or pattern-pieces, tracing chalk-marks for the guidance of the saw. The 'seasoning-room' is one which exemplifies the scrupulous care taken in the preparation of the wood before its employment in the manufacture. Every separate piece, after having been exposed to the air for some years, is before final use brought into this room, and kept for a long time exposed to a temperature of about one hundred degrees until the fibres are brought to a state of dryness as complete as can be obtained. The 'seasoning-room' is heated by hot-water pipes, and it is also provided with a steaming-tank for steaming planks which are to be bent to any required curve.

Another portion of the lower floor of this range is occupied by 'hammer-makers,' workmen employed in making the minute and complicated mechanism by which the keys are brought into connexion with the strings. 'Cleaners-off' and 'polishers' occupy other portions of the floor; their employments, as the terms seem to imply, having reference to the instruments when in a nearly finished state. Adjacent to these are rooms in which finished instruments are placed before being sent from the factory. The middle floor of this range exhibits long workshops occupied by various classes of workmen, among whom are 'grand,' 'semi-grand,' 'cabinet,' and 'cottage sounding-board makers,' or 'belly-men,' whose office we have before alluded to; 'cottage-case makers,' and 'cabinet-case makers.' In continuation of the same story are shops for 'fitters-up' and 'top-makers,' the former of whom put together the various component parts made by other workmen, while the 'top-makers' fabricate the lids or covers of the instrument. On the upper floor are repetitions of some of the arrangements seen below, such as 'case-makers,' 'belly-men,' and 'finishers,' together with another class of workmen not yet spoken of—viz., the 'key-makers.' Contiguous to the northern end of this range is a series of sawpits, in which the logs are cut.

Proceeding through an archway westward we now come to the central court, occupied, like the eastern one, principally with piles and logs of mahogany. Open sheds, too, placed in various parts of the factory, exhibit an enormous quantity of wood, most of which is of a fine and valuable character. The value and importance of the stock of timber kept on hand in an establishment of this kind rest on two grounds, the beauty and excellence of the wood itself, and the necessity for allowing every plank and log to be thoroughly seasoned before use.

The log lies a long time before it is cut into planks; the planks are left through another long period before they are cut into shape for use; and the pieces thus cut are again left some time to season: so that almost every piece of wood employed in a pianoforte remains in the factory several years before it is finally used. This entails an enormous investment of capital; for there is on the premises a stock of wood sufficient for two years' manufacture, equivalent to about five thousand pianofortes.

The workshops on both sides of the middle court exhibit scenes of busy industry similar to those before noticed. There are 'case-makers' and 'belly-men,' 'fitters-up' and 'polishers.' Besides these there are, in the east central range, a 'veneer store-room,' in which valuable fancy-woods are kept; shops for 'hammer-makers,' 'hammer-rail makers,' and 'desk-makers.' At the northern end of this range is an engine-house, and also a shed for mahogany logs. Some of the buildings, too, have flat leaded roofs, on which timber is placed for the better exposure to air and sun. Near the principal entrance to the premises, and in the same range, is the store-room of the principal foreman, in which all the smaller articles required in the manufacture are kept. This room, and the whole arrangements connected with it, are conducted on the most scrupulous system, an indispensable requisite where several hundred workmen are to be supplied with working materials.

On the opposite side of the middle court is the range which, for the sake of distinction, we will term the west central range. Our frontispiece presents a view through part of one of the workshops in this range, and will serve to convey some idea of the general appearance of these extensive shops. It is one of the 'cabinet finishing shops' where the cabinet pianofortes go through some of the later processes of the manufacture: for the sake of clearness, only one-half the length of the shop is shown in the cut.

The shop just alluded to is on the middle floor of the west central range; the upper floor being occupied by 'square-case makers' and 'belly-men;' and the lower by 'regulating and tuning rooms,' a 'glue-room,' a 'rosewood store,' and a 'veneer-room.' In this latter room we saw, among other costly specimens of veneer, some slabs or sheets taken from a tree which has had much notoriety, and which strikingly illustrates the value placed upon fine wood. Logs for veneers are valued partly on account of the beauty of the pattern or figure, and partly on account of the size and soundness of the veneers which may be cut from them; and in the instance here spoken of the two qualities were combined in an unprecedented degree. It is generally known that Honduras mahogany is not so highly valued for cabinet-work as Spanish mahogany; it is therefore in the pianoforte manufacture used for some of the parts which are afterwards veneered with Spanish mahogany, rosewood, or some other kind of fancy wood. But in the present case a tree of Honduras mahogany, imported about sixteen years ago, has far exceeded in beauty any specimen of Spanish wood. The circumstance was thus alluded to in one of the volumes of the 'Library of Entertaining Knowledge,' a few years ago:—"Spanish mahogany is decidedly the most beautiful: but occasionally, though not very often, the Honduras wood is of singular brilliancy; and it is then eagerly sought for, to be employed in the most expensive cabinet-work. A short time ago Messrs. Broadwood, who have long been distinguished as makers of pianofortes, gave the enormous sum of three thousand pounds for three logs of mahogany. These logs, the produce of one tree, were each about fifteen feet long, and thirty-eight inches wide. They were cut into veneers of eight to an inch. The wood, of which we have seen a specimen, was peculiarly beautiful, capable of receiving the highest polish, and, when polished, reflecting the light in the most varied manner, like the surface of a crystal; and from the wavy form of the fibres offering a different figure in whatever direction it was viewed."* The price, we have been informed, is here erroneously stated at three thousand pounds: it was about two thousand, averaging nearly five guineas per cubic foot! The figure of this wood somewhat resembles the ripple or small waves of water gently moved by the wind; and perhaps from this circumstance it has obtained in the factory the name of 'ocean-wood.'

An archway under the west central range leads us to the western court, which will terminate our tour of the premises. The workshops on either side of this court exhibit, in addition to some similar to those before noticed, a 'turner's shop,' where the legs for pianofortes are turned; a 'stringer's shop,' where the strings are attached to some of the instruments; and shops wherein are made a number of minute pieces of mechanism connected with the keys, such as hammers, dampers, &c. This open court, too, like the others, has its stores of timber; and at one end of the west central range is a series of about ten or a dozen sawpits, where the logs are cut into planks.

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* 'Timber Trees,' p. 175. 1829.

It would be no easy task, nor indeed would it be necessary, to describe the arrangements of the various departments of workshops. It may suffice to say that they bear some resemblance to the shops of a cabinet-maker, in relation to the materials and the tools employed. The work-benches, about three hundred in number, are placed in general transversely, with one end towards the windows; and on the side opposite to the windows are the stoves and fire-places for warming glue, and other operations in which heat is required. Overhead, in nearly all the shops, are piles of wood in various stages of preparation for the use of the workmen, and undergoing the last process of seasoning by the warm temperature of the shops. A better idea of the nature of the several employments may perhaps be gathered by tracing, in a cursory way, the progress of a pianoforte in its several stages of manufacture.

Whatever form or value the pianoforte may have, it consists of a case containing stretched wires, which wires are struck by soft hammers, attached to the hindmost end of the finger-keys. This being the general character of the instrument, the various subdivisions are as follows. It was stated in a former paragraph that the *harpsichord* was an improvement on previous instruments, by having two strings to every note: this improvement has been retained in the pianoforte, together with the later one of having soft hammers instead of quills. The "tinkling grandfather of the pianoforte," as the *clavichord* has been called, had but four or five octaves; the harpsichord five or five and a half; but the pianoforte has extended its range to six and a half. These points being remembered, then, we may state, 1st. That the *square* pianoforte has the strings horizontal, in a rectangular case, with two strings to each note, and a compass varying from five and a half to six and a half octaves. 2nd. The *cottage* pianoforte has its strings arranged vertically, reaching nearly from the ground to a short distance above the level of the keys; the case is much shorter than in the square; there are two strings to each note; and the compass is generally six octaves. 3rd. The *cabinet* pianoforte is much higher than any other, except the *upright grand*, a form not now manufactured; the strings, two to each note, are ranged vertically, but, unlike those in the *cottage* form, are elevated wholly above the level of the keys; in general the compass is six octaves, but the most finished instruments have a compass of six and a half. 4th. The *grand* pianoforte is longer than any other; it is wider at one end than the other, and, unlike those hitherto mentioned, has the keys at one end; the strings are horizontal, and the chief feature whereby the instrument is distinguished is, that there are *three* strings to each note; the compass is always six octaves and a half, and there are thus upwards of two hundred and twenty strings. 5th. The *semi-grand* pianoforte is, as its name imports, a modification of the 'grand;' it has the strings horizontal; its case somewhat resembles that of the 'grand,' but it is shorter, has a compass of only six octaves, and has but two strings to a note. These are the five forms of pianoforte now made; and the manufacture of course involves certain modifications to suit the various forms. As a means of showing the relative proportions in which these several forms are manufactured, we find that out of the eighty or ninety thousand pianofortes which have been made by this firm, there have been, to every hundred 'squares,' twenty-eight 'grands,' sixteen 'cabinets,' nine 'cottage,' and five 'upright-grands' and 'semi-grands;' so that the 'squares' constitute nearly two-thirds of the whole number.

The *case*, being a hollow box veneered on the outside, is made in a manner nearly similar to cabinet-work generally. In the 'square' form it is an oblong rectangle; in the 'cabinet' it is lofty; and in the other three forms it is modified in various ways. The most scrupulous care is taken in the selection of wood, not only in reference to its perfect dryness, but to the combining of two or three sorts together, so that each kind of wood may render its peculiar properties in aid of the others. Nearly all the work-benches at the factory are provided with a simple but valuable arrangement for pressing and keeping together the pieces of glued wood while drying. At a height of about four feet above the bench is a horizontal board or false ceiling; and the glued pieces being laid on the bench, a number of elastic wooden rods are placed nearly vertical between the false ceiling and the bench: being longer than the interval in which they are to be placed, they can only be adjusted by a slight bending or convexity in their length; and this bending gives them a very powerful pressure on the bench beneath, or on the glued pieces placed on the bench. In some instances we saw thirty or forty of these bent vertical rods employed on one piece of wood. When the glueings are dry, a slight blow or jerk will remove each rod.

Without attending to the technical names applied to the various parts of a pianoforte, we shall, perhaps, be understood by general readers when we speak of the *frame-work* of the instrument as distinct from the mere outer case. If we open a pianoforte, especially a 'grand,' we shall see bars and rods and strengtheners of various kinds, placed in different directions, not only with a view to give form and stability to the instrument, but to resist the powerful strain to which it is exposed by the tension of the strings. This tension is truly extraordinary, and requires for its due appreciation a little consideration of the phenomena of a stretched string or wire. Let us suppose that a wire is wound round two pegs or pins placed a yard apart, and that it is merely brought into a straight line without any attempt at stretching it. If struck with a soft hammer it will yield a low sound, due to a small number of vibrations per second; but if we wish to elevate the pitch of the tone, we can do so by increasing the tension or stiffness of the wire. A tuning-key being placed on one of the pegs to which the wire is attached, the peg can be turned round and a portion of the wire wound on it: this necessarily increases the tension of the portion of wire extending between the pegs; the increase of tension increases the rapidity of vibration when the wire is struck; and this increased rapidity gives a more elevated pitch to the tone elicited. Now, in conformity with one of the laws of force, the wire pulls with a power equal to that by which it has been stretched: it tends to regain the state which it originally had, and by this tendency exerts a powerful dragging or pulling force on the pins to which its two ends are attached, and on the frame-work wherein the pins are inserted. This force is exerted by every wire, according to the tension given to it; and the aggregate force is surprisingly great. It is calculated that the two hundred and twenty-five strings or wires of a grand pianoforte exert a strain of more than twenty thousand lbs.! This is in fact the force tending to draw together the two ends of the frame-work to which the wires are attached. It need hardly be observed, therefore, that the frame-work must be made with great strength. The various pieces of wood are in many places glued up, so that the grain of one component part shall extend in one direction, and that of the other at right angles to it; different kinds of wood are used in different parts; an iron rod is placed here, an iron plate there; and contrivances of various kinds are introduced to give most strength where most strain will be experienced. The 'action' of a pianoforte (of which we shall presently speak) is, perhaps, more complicated in a 'cabinet' than in any other form; but the mechanism connected with the strings is far more complex in the 'grand.'

The mere attachment of each wire to pegs at its two ends is not sufficient for the adjustment of its tone. The whole length of wire is not allowed to vibrate when struck, but only a given length of it from one end to a pin inserted in a curved piece of wood. The adjustment of these vibrating lengths to the different strings is a matter of great delicacy, and may perhaps be rendered comprehensible by the few following remarks. There are three modes of producing an elevation of pitch in a vibrating string: 1st, by shortening the string; 2nd, by increasing its thickness; or 3rd, by increasing its tension. Now the manufacturer does not adopt any one of these methods of adjusting tones, to the exclusion of the others: he avails himself of all. Twelve strings of the same length and thickness might be so different in tension as to yield the twelve semitones of an octave; twelve strings of the same thickness and tension might be of such different lengths as to yield the twelve semitones; or, lastly, twelve strings of the same length and tension might be made to produce these effects by having the thickness different. But in practice the tones produced by either of these methods would be very defective in character. Each degree of thickness, of length, and of tension produces its own peculiar effects on the '*timbre*,' or quality of tone. If two strings of the same length and thickness were so stretched as to produce tones differing by an octave in pitch, one would be strained nearly to breaking, and the other would produce a dull, weak, and smothered sound. If, while producing these two notes, the strings differed only in length or in thickness, the qualities of tone would not be so much at variance as in the case just supposed; but still the required equable character of tone would not be produced. The plan adopted, therefore, is, to let the length, the thickness, and the tension all vary together.

This explanation will enable us to understand the reason for the observed difference in the strings of the pianoforte. We perceive that the strings for the upper notes are not only shorter but also thinner than those for the lower; and we should find, though it is not perceptible to the eye, that the tension is likewise different. The thickness, the length, and the tension, all diminish (but not uniformly), from the lower to the upper notes; *tension* being here used to express the force employed in stretching the string to the required degree. In a grand pianoforte there are fourteen different thicknesses of wire;

the smaller, for the upper notes, being plain polished steel-wire; and the thicker, for the lower notes, being coated with a very fine coil of copper-wire.

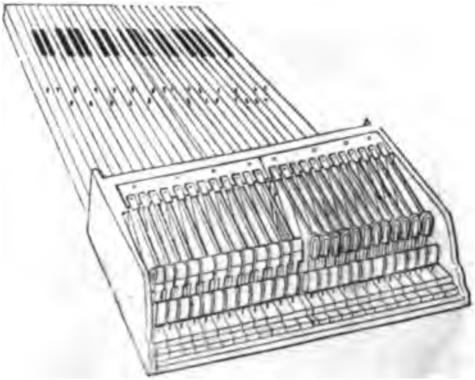
In adjusting the strings there are certain rules as to the thickness of wire selected for a certain note; and the vibrating length of each string is regulated by a curved piece of wood called a 'bridge,' fixed to the sounding-board of the instrument. To make and adjust this bridge is one of the most delicate operations of the 'bellyman' or 'sounding-board maker.' The curve itself is regulated by a gauge to which the maker works: so is the position which the bridge is made to occupy in the sounding-board; and so likewise are the order and arrangement of the pins inserted in it. These pins are so placed that the strings rest against them, each string being bent out of its rectilinear course by coming in contact with a pin. A portion of the string is thus effectively cut off, so far as regards the vibration; and the manufacturer is thus enabled, by the adjustment of the pins in the sounding-board, to give to the strings any vibrating length corresponding to the tones to be produced. So complex and important are these arrangements, that the strings of an improved grand pianoforte require nearly one thousand iron pins or pegs, each one inserted in a hole made with great exactness to its dimensions. The workmen called 'stringers' fix the proper strings to the proper pins. The wire is sent from the wire-drawer in coils about five or six inches in diameter, each coil containing enough wire for several strings.

Hitherto we have said nothing of the mechanism by which the strings are struck,—by far the most curious part of a pianoforte. This mechanism obtains the general name of the 'action;' and when we hear of 'square action,' 'grand action,' &c., we must understand these terms to allude to the particular mode in which the percussion is effected. It is perhaps scarcely too much to say that three-fourths of the improvements which the pianoforte has undergone during the present century have had relation to the 'action.' All the great firms for which the metropolis is distinguished in this branch of manufacture have brought forward some or other improvements in this respect; and their united labours have raised the instrument to such a stage of perfection, that—like the chronometer—there is little more to be wished for, unless indeed it were possible to obtain the *sustained* tones of the organ.

The most obvious part of the 'action' is the key-board and its mechanism. Every ebony or ivory key is a lever, which, when pressed down at the foremost end, rises at the hindmost, and this leverage is the source of all the effects subsequently produced. A little examination of these keys will show that the ebony is solid, but that the ivory is merely a veneer or surface put on a substratum of wood. The white keys are made of carefully prepared lime-tree wood, which is cut after the pieces of ivory are attached. Fig. 2 shows the appearance of the key-board while being cut up into keys. The pieces of ivory are shaped and prepared by the ivory-worker to the exact size for each key, and are glued side by side on the surface of the wood. The wood is marked out by a gauge, and is then cut up into parallel pieces for the keys, by means of a slight frame-saw. A notch is made in the stem or shaft of every white key, to receive the ebony key and its stem. When all the keys are cut, a little piece of mechanism is placed in one particular part of the length of each, to form a fulcrum or pivot.

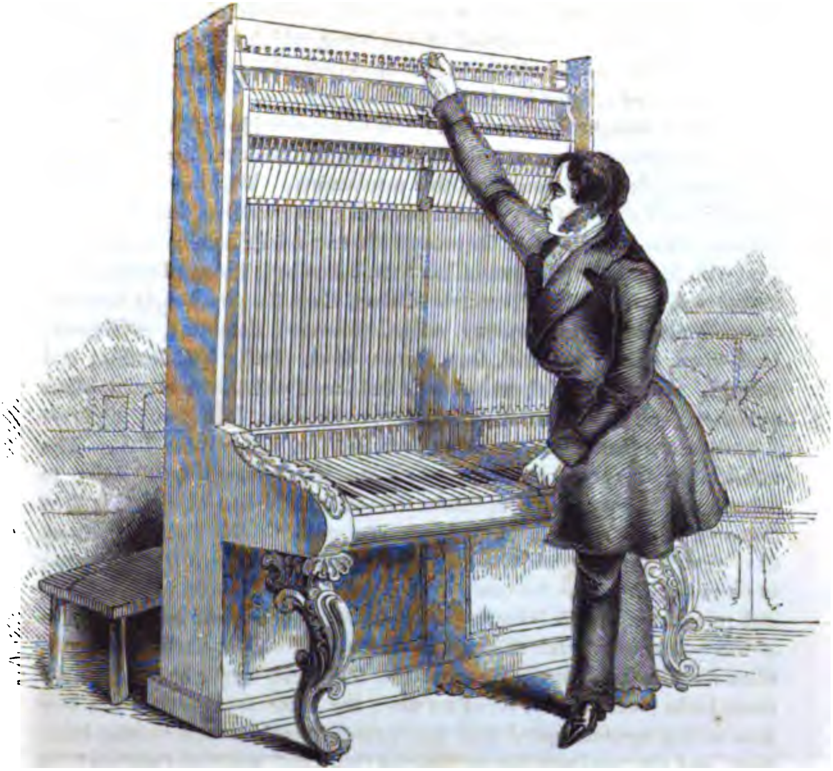
Key-cutter at work.—Fig. 2.

To the hindmost part of each key is attached the mechanism whereby it is made to act upon the string; and this mechanism, to which the name of the 'action' is more particularly applied, presents a complexity of arrangement that will baffle everything like a popular description. Simple as the 'square' pianoforte is when compared with the other forms, yet Fig. 3 will show that the 'action' attached to each key is anything but simple. This cut represents a 'square treble-action,' that is, such a portion of the keys and connected mechanism as belong to about three octaves of the 'treble' or upper part of the instrument. This piece of mechanism is represented as viewed from behind, the most favourable position for displaying the intricacies of the 'action.' It is seen that there are a number of small pieces placed at various angles, and acting upon one another by various species of leverage.



Treble-action of Square Pianoforte.—Fig. 3.

But this 'action' sinks into insignificance when compared to that of a cabinet pianoforte in its most improved form. We know of few contrivances, except a watch, or a bobbin-net machine, to rival the latter in intricate combinations. One part of the mechanism attached to each key is to cause the hammer to strike on the string; another is to regulate the degree of strength or softness with which the blow is struck; a third is to prevent the rebound of the hammer after the blow; and others are to produce modifications of effect so minute that nothing but the most refined skill in pianoforte-playing could render them either appreciable or necessary. Indeed the advance of the manufacture, and the advance of the players in skill, reciprocally measure each other: for while on the one hand the resources of the instrument were never thoroughly known until a Liszt, a Thalberg, a Herz, or a Moscheles developed them; so on the other hand these great players would never have been able to produce the exquisite effects for which they are so celebrated, unless the manufacturers had made important and repeated advancements in the progress of the instrument towards perfection.



The 'Action' or Internal Mechanism of a Cabinet Pianoforte. —Fig. 4.

Fig. 4 illustrates the general appearance which the 'action' of an improved cabinet pianoforte presents before the silken covering is applied. Yet this 'action,' complex as it appears, can give but a faint idea of the minute details involved in the mechanism. Nearly the whole of the long slender rods, the levers, &c., here seen have nothing to do with the striking of the strings: they relate merely to the production of some of those delicate effects, those minute shades of tone, which are not sought for in the average style of instruments. The mechanism here seen forms the 'front action;' and on this being removed, another series, still more complex than this, is displayed; and on the removal of this latter, which is the 'action' properly so called, we see the strings themselves, the percussion of which is the object of all this intricate assemblage.

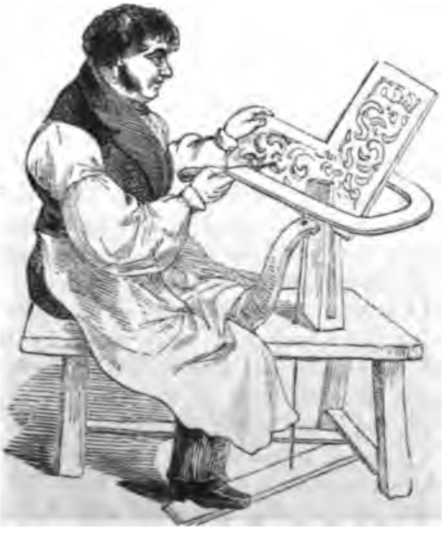
We have thought that the matter now under consideration could not be better illustrated, for general readers, than by ascertaining the number of separate pieces concerned in this mechanism. This has been kindly done for us by one of the superintendents; and we find that in one of Messrs. Broadwood's most improved six-and-a-half octave pianofortes (for which, we believe, a patent has been taken out) the mechanism connected with the 'action' consists of about *three thousand eight hundred* separate pieces of ivory, ebony, cedar, sycamore, lime-tree, mahogany, beef-wood, oak, pine, steel, iron, brass, lead, cloth, felt, leather, and vellum. Every one of these has to be fashioned with the most scrupulous exactness, and as scrupulously adjusted to its place. Many of the pieces are not more than a quarter of an inch square, some even less. The qualities of all the varieties of wood are closely studied, in order to determine their particular aptitude for the different parts, and it is thus that so many as seven or eight kinds are used in the 'action' alone. One kind is preferred because slender rods made of it will not warp; another kind because the grain is straight; a third because it is hard and smooth; a fourth because it is soft and smooth; and so on. Some of the rods are as much as three feet long, and only a sixth or seventh of an inch in thickness. To give the technical terms applied to all these little pieces would be of no use; for after saying that the key acts on the 'grasshopper,' and the 'grasshopper' on the 'under-hammer,' and the 'under-hammer' on the 'sticker,' and the 'sticker' on the 'hammer,' and the 'hammer' on the string, we have done but little towards explaining the particular construction and action of each.

When we say that all these minute pieces are fashioned and adjusted by hand, it will be readily conceived that an important part of the arrangements of the factory has reference to them. One of the workshops is entirely occupied by the 'key-makers,' who prepare the lime-tree of which the body of the key is made, glue on the pieces of ivory, cut the keys to their required widths, arrange the little pin or fulcrum, &c. Other workmen make the slender cylindrical rods of pine or of pencil cedar. Some are forming the 'hammers,' others the 'under-hammers,' the 'dampers,' the 'grasshoppers,' &c. An important and very curious part of the labour is the adjustment of the little pieces of vellum, cloth, felt, and leather. Vellum is used for the hinges of some of the minute parts; the two ends or edges of the vellum being glued into slits in the two pieces which are to be hinged together; and it thus forms a hinge peculiarly delicate in its action. The little pieces of cloth are used in various ways for subduing the rattling sound which pieces of mechanism would be apt to produce, and which would interfere with the tones of the instrument. To such a degree of refinement is this carried, that small holes not above a twelfth or fifteenth of an inch in diameter are lined with cloth in order to give a smoothness to the motion of a wire which passes through the hole. The felt and the leather are principally employed as coverings for the hammers and dampers which come in contact with the wires, and which are thus covered to give mellowness to the tone. If a stretched wire be struck by a piece of wood or of metal, two sounds are heard—one due to the vibration of the wire itself, and the other to the blow which the striking substance gives: to get rid of this latter sound is the object of leathering and felting the hammers. The felt used for this purpose at Messrs. Broadwood's, and which is a beautifully soft white substance about a fourth or fifth of an inch thick, is said to be made from the wool of sheep reared on Prince Esterhazy's estate in Hungary, the quality of this wool having been found admirably adapted, from its softness, for this purpose. This is not the least remarkable of the instances which show how manufactures, when left to regulate themselves, set distance at defiance, and draw together commodities from all quarters.

In speaking of the strings for the various forms of pianoforte we stated that the 'grand' has three strings to each note, and that each of the other four forms has two. The adjustment of all these strings is an important matter, and devolves upon the 'regulators' and 'tuners.' It will of course be understood that in such a case the two or three strings belonging to one note must be tuned in unison; and to effect this the strings are, as may be supposed, of equal lengths and thicknesses. The object then is to bring them to an equal degree of tension, by which the tones may be of the same pitch. The persons employed at this avocation are such as are able, from accuracy of ear, to determine musical intervals with much precision. In Fig. 4 the 'cabinet' pianoforte is represented as undergoing the process of tuning. We may here remark that the 'regulation' involves something more than the determination of the musical intervals between the several tones: it relates also to the easy and proper action of the keys, and the general fitness of all the parts for the office which they are to serve.

A portion of pianoforte mechanism to which we have not yet alluded is that connected with the *pedals*, resembling all the other portions in the high degree of care necessary in the manufacture. These pedals serve two totally distinct offices, one of which relates to all kinds of pianofortes, and the other to those only which are provided with three strings to every note. The first govern the 'dampers,' and their use may be thus explained. In order that the harmonies in a piece of music may produce their due effect, it is necessary that the preceding notes should not continue to sound long after the keys have been struck, else discord may usurp the place of harmony. For instance, if the note C were sounded, and the next note of the piece of music were D, the continued sounding of the C after the D has been struck would give the discordant interval of a second, which the ear cannot tolerate, except as a foil to more perfect intervals. Hence mechanism is provided, whereby a soft hammer or 'damper' is made to fall on the vibrating string directly the finger is removed from the key, and this damping smothers the note by stopping the vibrations. As, however, it is desirable in some pieces of music to have the full effect of the vibrating strings after the fingers are removed from the keys, the player is enabled, by pressing his foot on a pedal, to remove all the 'dampers' from the strings, with which they do not again come in contact until the pedal is released. In some of the older square pianofortes this adjustment is made by means of a handle situated near the left hand of the player; but we believe that in all the modern instruments a pedal affords the requisite leverage. The other kind of pedal, used only in grand pianofortes, is employed for the purpose of removing one out of every three strings from the action of the hammers. If three strings were struck by a hammer every time that the key belonging to that hammer is played upon, the player could not obtain the *piano* passages which add so much to the grace and effect of music. There is, therefore, a provision for lessening the quantity of sound—for such is in reality the operation—by lessening the number of strings struck by each hammer. This is effected by shifting the entire key-board to a small distance from its usual position, whereby each hammer clears one of the three strings, and only strikes the other two. The foot-pedal effects this shifting by intermediate levers, and the player has thus the whole arrangement within his power.

Among the minor operations in the manufacture is the preparation of fret-work or open-cut boards for the front of some kinds of pianofortes. This is effected in a very quick and elegant way. The device being marked on the board with chalk, the board is fixed vertically in a kind of vice, and, as represented in Fig. 5, is sawn by means of an extremely fine and thin saw, which follows all the turnings and windings of the chalk-marks, penetrating to every angle, however acute, and severing the small pieces, the absence of which constitutes the pattern. The other ornamental features we must dismiss without any particular notice, as involving no principle but that which distinguishes common cabinet-work. We may, however, notice that the turned legs for the better kinds of instruments are produced by a beautiful lathe, the action of which is of a highly scientific order. An hexagonal or octagonal pattern is produced in a circular leg, by allowing the leg to remain stationary, and making the cutting tool revolve rapidly at such a distance from it as to cut away one-sixth or one-eighth of the surface. The cutting tool has at the same time a



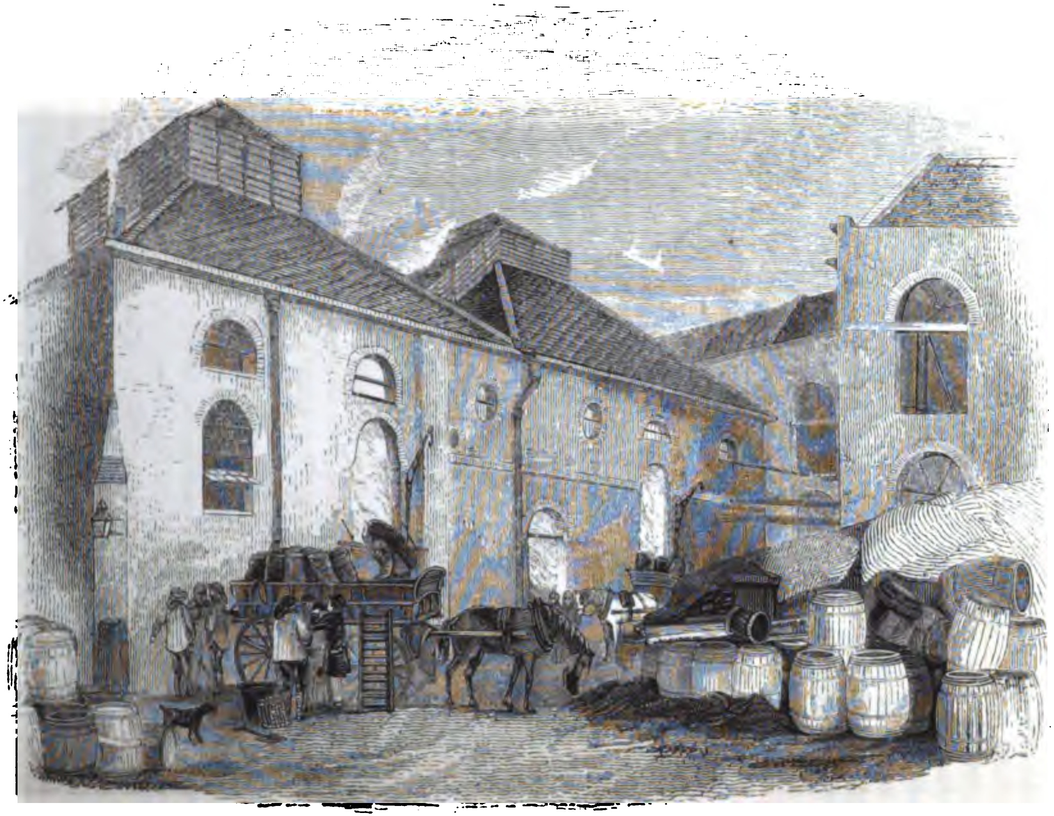
Fret-cutter at work.—Fig. 5.

motion backward and forward in the direction of the length of the leg. The principle of action very much resembles that of the wheel-cutting engine in the clock-factory.

When the various component parts of the pianofortes are put together, the tones regulated to something like accuracy, the exterior adorned with polishing, carved ornaments, &c., and all rendered nearly complete, they are conveyed to another establishment belonging to the same firm in the neighbourhood of Golden Square. Before we follow them to this last depository, we will mention a circumstance which struck us during the visit to the factory at the Horseferry Road, and which is worthy of notice: we mean the precautions taken to prevent fire. Wherever large quantities of dry wood are used, such precautions are highly necessary; but we seldom remember to have seen them carried out on such a complete system. In many parts of the factory brick party-walls are carried from front to back, and across the opening which connects one department with another is a sliding iron door, carefully closed every night; so that the connection is entirely cut off from one to another. For the use of the workmen who have to melt glue, &c., there are about fifty large German stoves: these are each entirely surrounded by a high iron fender, which rests on stone or brick-work, separated by sheet lead from the wooden floor beneath; so that the heat from the stove is most effectually cut off from the floor beneath, and, being close stoves, no sparks can fly about. For the process of veneering, and others wherein an open fire is required, large fireplaces, about thirty in number, are provided: these are surrounded by and based on brick; and in the front of each is a heavy sliding iron door, working vertically in grooves and balanced by weights. The door can be lowered in an instant, whereby the fire is not only completely shut out from communication with the shop, but, being deprived of draught, must necessarily decline. Each fireplace is for the use of a certain number of men, all of whom take by turns the office of seeing that a bucket of water stands by the side of the fireplace, and of closing the iron door on leaving work. The superintending foreman visits all parts of the factory every evening after the men have left, and if any one of the sliding doors is seen open, the man whose turn it was to attend to it is subjected to a fine. If, notwithstanding these precautions, a fire should break out, a fire-engine, a coil of leathern pipe, a plug connected with the water-main, and other mechanism of a similar kind, are at hand, and can be brought to bear upon any part of the factory at a few minutes' notice. These are arrangements such as it would be well to adopt in every well-ordered factory.

The music-vans which bear the name of "Broadwood" are employed not only to convey pianofortes to the houses of the purchasers, but to convey them in the first instance from the factory in the Horseferry Road to Great Pulteney Street, Golden Square, where is the original establishment belonging to the firm. Before the great extension in the use of the pianoforte, the operations of the firm were wholly carried on in Pulteney Street and in a range of buildings extending from thence to Golden Square; but now, although there are here upwards of a hundred and fifty persons employed, the pianofortes are principally made at the factory which we have just left. The stock of instruments required to be kept on hand is so extremely large, that a wide range of ware-room is necessary. Almost every room in two large houses in Pulteney Street and one in Golden Square is occupied either in this way, or else by tuners who are giving the final regulation to the tones of the instruments: this adjustment cannot be effected in a large room where many are similarly employed, on account of the confusion of sound which would result; and there are therefore seldom more than two tuners in one room. Some of the apartments are store-rooms for 'grand' pianofortes; some for 'cabinet,' some for 'cottage,' some for 'semi-grand,' some for 'square;' others are for second-hand instruments. A large range of workshops is principally occupied by workmen engaged in 'grands,' the internal mechanism of which is prepared here; others are repairing and adjusting stock pianofortes, many hundreds of which are kept ready for hire. On the ground-floor are ranges of counting-houses and offices, for the cashier, clerks, collectors, &c., belonging to the establishment; in one of which we noticed a portrait, by Hogarth, of the original proprietor of the establishment, a picture which has probably occupied its present place for more than a century.

The pianoforte manufacture is one in which nothing but highly-skilled manual dexterity can make and adjust the numerous pieces of mechanism involved in it; and those workmen who possess this skill are not likely to be supplanted by any automatic machinery. Hence it happens that the same workmen are seen, year after year, occupying their old benches, using their old tools, coming to work and leaving work at the old hours, and seeming as if the old shop belonged to them and they to the shop. We noticed, not only that many of the workmen in the factory are elderly men who have occupied their present situations twenty, thirty, or forty years, but that a kindly feeling prevailed among all, illustrative of mutual confidence between the employers and the employed. The patriarch of the establishment is a venerable *ci-devant* foreman, not far from ninety years of age, who has seen out two or three generations of workmen, and whose connection with the establishment dates back through a period of nearly sixty years. That such a man is respected by the firm, and deemed almost part and parcel of it, need hardly be said.



XVIII.—Gas Works—Horseferry Road.—Face p. 411.

XVIII.—A DAY AT THE WESTMINSTER GAS-WORKS.

What Dr. Arnott says of the water-pipes of London, ramifying through every street, and lane, and alley, and distributing their valuable contents to the dwellings of its inhabitants, we may to a certain extent say of the pipes through which our supply of gas is obtained. "The supply and distribution of water in a large city, since the steam-engine was added to the apparatus, approaches closely to the perfection of nature's own work in the circulation of blood through the animal body. From a general reservoir a few main pipes issue to the chief divisions of the town; these send suitable branches to every street, and the branches again divide for the lanes and alleys; while at last into every house a small leaden conduit rises, and, if required, carries its precious freight into every apartment, where it yields to the turning of a cock." The analogy is true so far as regards the emanation from a centre, the branching out of minor pipes from those of larger diameter, the lateral small pipes leading into the houses, and the concealment of the whole assemblage beneath the pavement and road-way; but the subsequent movement from the branches back again to the centre,—though observable in the flow of water through drains into the rivers and seas, the evaporation from thence, and the feeding anew the springs from which the supply was originally obtained,—is not so observable in the gas circulation.

Be the analogy what it may, however, no thinking person can fail to be struck with the admirable means whereby our cities and towns are now lighted. So far back as the year 1823, when gas companies were comparatively in their infancy, a Committee of the House of Commons spoke highly of the system of lighting streets by gas, as a measure of street police; and there can be no question that the doers of evil, who "love darkness rather than light," infest the streets of London not only relatively, but positively less now than before the introduction of gas, although the inhabitants have increased three or four hundred thousand in number. The beauty and convenience of the light afforded by gas in streets shops, and buildings are appreciated by all;

but the protection which it gives, though not so fully understood, is not less worthy of notice.

The establishment to whose arrangements the details of this paper are devoted is the Westminster station of the "Chartered Gas-light and Coke Company." It bears in many respects the same relation to the gas-manufacture which the Soho factory bears to the steam-engine manufacture. It was the establishment which first had to bear the brunt of all the obstacles attending the public use of gas, the difficulties in the production of gas sufficiently pure for purposes of illumination, the difficulties attending the transmission of gas from the works to the houses and buildings, the enormous expense involved in the prosecution of experiments, and—perhaps the most difficult of all—to overcome the prejudices existing in the public mind. It is not more than forty years ago that a Mr. Winsor drew the attention of the London public to this mode of lighting streets and houses, after it had been essayed in a few other parts of England. He lectured on the subject at the beginning of the present century, and formed a "National Light and Heat Company," which, though built upon rather fanciful grounds by the projector, became the parent of all the gas companies, and has ever since taken the lead among them. The works were established at Westminster, forming a portion of the present large station there. Mr. Matthews, who wrote a history of gas-lighting about fifteen years ago, takes the following view of the establishment of Mr. Winsor's company, which had become a chartered body:—"Various and plausible as were the objections urged against it at the time, experience has proved that the property of any individual was neither adequate to the magnitude, nor likely to be risked in such large and expensive undertakings; and this was shown by some facts adduced in the evidence to support the bill. By calculations that were made from actual surveys, it appeared that the expense of laying down pipes for the city of Westminster alone would be one hundred and fifty thousand pounds, without including anything else. There were also other circumstances that entitled this company to particular attention; for, previous to this period, their experiments for making, purifying, and applying the use of coal-gas to the purposes of lighting had been made on a large and expensive scale. And although the public had been partially benefited from the knowledge obtained by their means, hitherto no pecuniary advantage had resulted to themselves, notwithstanding their zealous exertions to improve and introduce the art of gas-lighting. However, the hope of future benefits animated them in their further efforts to attain their object. Perseverance enabled them to overcome the great difficulties which attended their pursuits; the success of their endeavours has excited and encouraged others to engage in the same course, and imitate their example; and how many similar companies may trace their origin to the stimulus produced by the successful establishment of this!" The buildings which had been erected at the Westminster station before Mr. Matthews wrote, together with those which have been subsequently added to it, have cost no less a sum than three hundred and fifty thousand pounds.

The western station of the Chartered Company (the other two stations being at St. Luke's and near Shoreditch) occupies an oblong plot of ground, upwards of three acres in extent, lying on the northern side of the Horseferry Road, at no great distance from the Millbank Penitentiary. It was probably in the open fields when first built; but streets have been gradually formed around it. The general arrangement of the buildings is this:—there are two open squares or quadrangles connected by an arched passage; both the quadrangles are surrounded on all four sides by buildings, and the larger or southern quadrangle has in addition a large isolated building occupying its centre. The various masses of buildings have been erected at different times, as the operations of the company extended, and serve as a kind of memento of the successive steps by which this great social improvement has been wrought.

It will facilitate our comprehension of the arrangement of the establishment if we first briefly enumerate the steps by which gas is produced. 1st. The carburetted hydrogen, which constitutes the gas for illumination, is one of the ingredients in common coal, and is separated from it by distilling the coal in highly heated vessels secluded from the access of atmospheric air. 2nd. The substance left behind in the heated vessels or retorts, after the volatile portions have separated from it, forms the fuel known as *coke*, which is either sold to other parties, or is used, with or without admixture with coals, to heat the retorts. 3rd. The volatilized ingredients are so far from being pure carburetted hydrogen, that they comprise tar, ammonia, sulphuretted hydrogen, and other substances, all of which must be removed before the light-producing ingredient will be in its proper degree of purity; and the first part of this purification is effected by a piece of apparatus called a "hydraulic main," in which the coarser impurities larger number, we believe, than has been congregated in any other place, although some establishments have individual gasometers of larger capacity. Persons to whom the arrangement of gas-apparatus is not familiar are often surprised at the different appearance which a gasometer, as seen towering above the wall of a gas-factory, presents at different times. At one period a kind of scaffolding of light and elegant iron-work is seen, forming a triangular space, within which an enormous cylinder stands at a small height from the ground; at another time, perhaps, after an interval of a few hours, the cylinder will be seen to have ascended ten or twelve feet; and at a subsequent period to have ascended nearly to the top of the framework, forty or fifty feet in height. These differences may be easily understood if it be borne in mind that a gasometer consists in reality of two vessels, one within another, the outer one being a tank open at the top and closed at the bottom, and the inner one being an inverted vessel open at bottom and closed at the top. The tank is filled to a certain height with water, into which the inverted vessel dips, so that the interior of the latter is cut off from communication with the external air by the interposition of the water. A pipe passes into the tank quite through the water, and terminates in the vacant space within the cylinder; and through this pipe the gas, when completely made and purified, is conducted. Now as carburetted hydrogen (common gas) is not half so heavy, *i.e.* has not half the specific gravity, of atmospheric air, a certain bulk of it collected in the cylinder gives an ascensive power to the latter, notwithstanding the ponderous character of the metal; and the cylinder rises higher as the quantity of the contained gas increases. Balance-weights are suspended outside the gasometer to counterbalance in a certain degree the weight of the iron cylinder; and these weights are so adjusted as to give to the gas a pressure or elastic force slightly greater than that of the atmosphere. The reason of a gasometer rising, then, when full, is that the iron gasometer with its included carburetted hydrogen is lighter than an equal bulk of atmospheric air. Fig. 2 may represent the principle of action in a simpler form; *a* being the receiver or cylinder, dipping into the tank *b*, and working against friction-wheels *f*; it is balanced by a counterpoise *e*, passing over pulleys *d*. The gas enters by the pipes *c*.

The tank of a gasometer is made of cast-iron, while the gas-holder is formed of sheet-iron, the sheets being riveted at the edges, and a piece of string being inserted at every joint, to make it air-tight—a domestic fireplaces we know that one kind of coal will concrete into a mass by a sort of semi-fusion, forming cinder; while another sort will burn away to a white ash without producing cinder. Similar differences exist in the combustion of coal in retorts; and the gas manufacturer for the most part rejects that quality which will burn away to a white ash. One portion of the coke produced at the Westminster station is afterwards used in the ovens or furnaces to heat the retorts, and the remainder is sold to manufacturers, dealers, and private persons. The 'coke-office' is the place where all the arrangements connected with the sale of the coke are carried on; while the clerks in the 'light-office' similarly manage the dealings of the Company with the gas consumers.

The two offices just named lie at the southern end of the large quadrangle or court; and from them we will proceed to the other buildings, turning to the right after passing the entrance-gates. At and adjacent to the south-east corner are four of those bulky vessels which form the most conspicuous objects in a gas-factory. The term *gasometer* applied to these vessels is a very inappropriate one, inasmuch as it conveys an idea of measurement as connected with the purpose of the vessel; whereas the gasometer is in truth nothing more than a gas-holder, in which gas may be accumulated and stored. In the earlier history of the manufacture, however, the gas-holder was made to serve the purpose of a gas-measurer, by the addition of a scale of feet and inches, so that the depth of gas in the vessel, multiplied by its area, gave the cubic contents; and thus the term 'gasometer' became introduced. So far as regards the quality and efficacy of the gas, a gasometer might be dispensed with, the gas being conveyed at once from the purifiers to the mains and burners; but it would be impossible thus to regulate the supply to the varying demand. On the same principle as a shopkeeper provides a store of goods more than sufficient for immediate demand, in order that he may be prepared for future fluctuations, so must the gas-works accumulate during the daytime a quantity of gas adequate to the enormous and sudden demand which occurs about dusk. From the first establishment of gas-works it was found necessary to provide this reserve store, but it was hoped that some means would be discovered of dispensing with the bulky gasometers. Such means have, however, not been found, and all the gas-works exhibit these capacious reservoirs. At the Westminster works there are no fewer than twenty of these, a larger number, we believe, than has been congregated in any other place, although some establishments have individual gasometers of larger capacity. Persons to whom the arrangement of gas-apparatus is not familiar are often surprised at the different appearance which a gasometer, as seen towering above the wall of a gas-factory, presents at different times. At one period a kind of scaffolding of light and elegant iron-work is seen, forming a triangular space, within which an enormous cylinder stands at a small height from the ground; at another time, perhaps, after an interval of a few hours, the cylinder will be seen to have ascended ten or twelve feet; and at a subsequent period to have ascended nearly to the top of the framework, forty or fifty feet in height. These differences may be easily understood if it be borne in mind that a gasometer consists in reality of two vessels, one within another, the outer one being a tank open at the top and closed at the bottom, and the inner one being an inverted vessel open at bottom and closed at the top. The tank is filled to a certain height with water, into which the inverted vessel dips, so that the interior of the latter is cut off from communication with the external air by the interposition of the water. A pipe passes into the tank quite through the water, and terminates in the vacant space within the cylinder; and through this pipe the gas, when completely made and purified, is conducted. Now as carburetted hydrogen (common gas) is not half so heavy, *i.e.* has not half the specific gravity, of atmospheric air, a certain bulk of it collected in the cylinder gives an ascensive power to the latter, notwithstanding the ponderous character of the metal; and the cylinder rises higher as the quantity of the contained gas increases. Balance-weights are suspended outside the gasometer to counterbalance in a certain degree the weight of the iron cylinder; and these weights are so adjusted as to give to the gas a pressure or elastic force slightly greater than that of the atmosphere. The reason of a gasometer rising, then, when full, is that the iron gasometer with its included carburetted hydrogen is lighter than an equal bulk of atmospheric air. Fig. 2 may represent the principle of action in a simpler form; *a* being the receiver or cylinder, dipping into the tank *b*, and working against friction-wheels *f*; it is balanced by a counterpoise *e*, passing over pulleys *d*. The gas enters by the pipes *c*.

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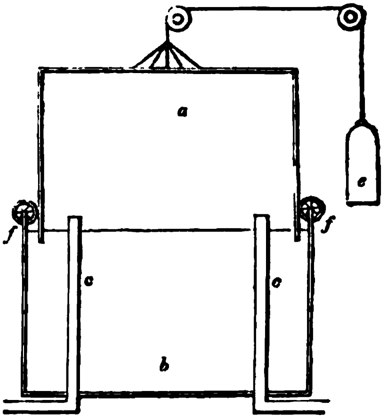

Fig. 2.

simple but valuable contrivance, suggested a few years ago by a workman. In some cases a strip of tarred canvas is inserted at the joints, or else canvas coated with white lead.

The four gasometers described as occupying the south-east corner of the quadrangle have what is termed the 'telescope' construction, in which there are two gas-holders, one within another, and both within the tank: the inner gas-holder is filled first, and then, by an ingenious contrivance, elevates the outer one as the gas continues to enter; the object being to gain a greater capacity without increasing the diameter of the vessels, since the increased height of the apparatus is not so costly as an increased ground area. The tanks of these gasometers are about forty feet in diameter and eighteen feet high; and the gas-holders when full reach to a height of nearly forty feet. About twenty years ago there were some strange misconceptions afloat respecting the danger to be apprehended from the explosion of gasometers; but in the Report of a Committee appointed to investigate the matter, the following remark set the doubts at rest:—"As long as every part of this reservoir is kept in good repair and perfectly tight, the pipes leading into and out of it maintained in proper condition, and plenty of water supplied, so that the parts which should be under water shall never be left bare, it seems to your Committee scarcely possible that any explosion should take place." The experience of subsequent years has shown that the gasometers are perfectly safe, and they are now made is then taken to a 'pug-mill,' a sort of churn, and there mixed up with clay, to form a cement or 'lute' for securing the covers of the retorts. The liquor is wholly evaporated, or driven off in the form of steam, by pouring it into shallow pans occupying the floor of the furnaces or ovens in which the retorts are heated. This mode, so far from being inconvenient, is productive of benefit in another way; for the steam arising from the liquor tends to cool the bars of the furnace, and thus to preserve them.

Next to this building is a carpenter's shop, in which wood-work for various purposes connected with the factory is made and adjusted. Adjoining this is a store-room for fire-bricks (used in the retort furnaces) and some other articles; and in the open area in front are two large vessels called 'saturators,' through which the whole of the gas passes after leaving the purifiers and before being conducted to the gasometers. The gas is, by a peculiar arrangement, subjected to a chemical process which gives it a very high degree of purity, by abstracting all the ammonia. This is a very recent improvement, under a patent obtained by Mr. A. Crole, superintendent of the Brick-lane station of this company.

We have now passed along the eastern side of the large quadrangle, from the north-east corner of which our frontispiece is taken. The building which occupies the principal part of the sketch is the central building before alluded to, through openings in which some indications may be seen of the fiery nature of the operations within. The buildings at the right are those on the western side of the quadrangle; while the foreground gives some idea of the busy scene which the whole place presents: here waggons laden with coals and passing to the coal-stores; there waggons and carts belonging to dealers in coke, who have come to purchase; in one place heaps of iron pipes; in another, of retorts, about to be put in the place of old ones; while men are bustling about in all directions. In crossing over to the western side, past the end of the central building, we catch an end glimpse of two of the retort-houses. Through a dark arch the eye can just discern the movements of men passing to and fro in front of the retorts, while an occasional gleam from the retorts themselves suddenly lights up the spot.

The western side of this quadrangle is occupied almost entirely by gasometers, enclosed in brick buildings without roofs. A portion of the space is however occupied as a coal-store, one of the many receptacles for the vast quantity of coals consumed here. A contemplation the brilliancy of the light, would produce a most disagreeable and unwholesome odour. Condensers of a great variety of forms have been used at different times and in different establishments; but those at the works under consideration consist of a pipe with a number of ascending and descending bends in it, and short pipes at the lower end to allow the tar and ammonia to flow out. A constant stream of cold water is flowing down the outside of each pipe, by which the gas, as it passes through, is cooled, and the condensible impurities separated from it. From the condenser the gas passes to the purifiers, of which there are three complete sets in the purifying-house, each set consisting either of three or four large cast-iron vessels.

In immediate connection with the building in which the condensing and purifying processes are conducted is an Artesian well, for supplying the establishment with water, of which a considerable quantity is required. The well is in the old form, excavated and bricked, to a depth of a hundred and twenty feet, after which it is continued by an Artesian bore to a farther depth of a hundred feet. This is one among the instances which will probably be greatly multiplied in future, of the substitution of a small bore in place of an expensive excavation; and rests on the simple but valuable principle that if the watery stratum lying between the clay and the chalk be reached, a small bore is nearly as effectual as a well several feet in diameter.

The rotating machinery in the purifying vessels, the working of the pump in the well, and the removal of the tar and ammoniacal liquor from one vessel to another, are effected by steam-power, which is afforded by two steam-engines, one situated under the roof of the purifying-house, and the other in the building occupying the central portion of the quadrangle. The connecting machinery by which this power is transferred to the purifiers comprises the usual arrangements of shafts, bevel-wheels, straps and bands, &c., and gives a busy appearance to the building.

The next building to the purifying-house is one in which the sulphuretted lime undergoes certain processes, after being removed from the purifiers. Some of the most important improvements in the gas manufacture relate to this part of the proceedings. The lime-water is conveyed from the purifiers to a large underground cistern, and from thence to a range of cast-iron vessels, in what is termed the 'pug-mill room,' where it is allowed to settle, by which the principal part of the lime subsides and separates from the sulphuretted liquor. The lime is then taken to a 'pug-mill,' a sort of churn, and there mixed up with clay, to form a cement or 'lute' for securing the covers of the retorts. The liquor is wholly evaporated, or driven off in the form of steam, by pouring it into shallow pans occupying the floor of the furnaces or ovens in which the retorts are heated. This mode, so far from being inconvenient, is productive of benefit in another way; for the steam arising from the liquor tends to cool the bars of the furnace, and thus to preserve them.

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The western side of this quadrangle is occupied almost entirely by gasometers, enclosed in brick buildings without roofs. A portion of the space is however occupied as a coal-store, one of the many receptacles for the vast quantity of coals consumed here. A contemplation of such immense supplies of fuel, and of the invaluable services derived therefrom, brings to mind the remark of an elegant writer, that the coal-mines of Britain "are, in effect, mines of labour or power; vastly more precious than the gold and silver mines of Peru, for they may be said to produce abundantly everything which labour and ingenuity can produce, and they have essentially contributed to make her mistress of the industry and commerce of the earth. Britain has become to the civilised world around nearly what an ordinary town is to the rural district in which it stands, and of this vast and glorious city the mines in question are the coal-cellars." Fears have been entertained by some that the time must be looked forward to when this precious supply will fail—when the mines, worked at their present enormous rate, will no longer yield their wonted product: but the more investigations are made, the more remote seems to be the time when such a misfortune will befall us; and we may safely leave to future ages the adoption of a remedy, if not a prevention.

We will for the present leave unnoticed the central building in the large quadrangle, and proceed through an arched entrance into the inner court, which is much smaller than the other, and without any central erection. On the right of the entrance is a store for timber and other materials. At this part of the premises is another series of condensing and purifying apparatus, comprising vessels similar to those before described, as well as an ammonia tank, pumps, &c. Beyond these, on the right, is a large smiths'-shop, where men are busily engaged in the repair and adjustment of various articles used in different parts of the works. The gasometers, condensers, purifiers, tanks, retorts, mains, pipes, and other iron-work of magnitude, are of course made at the large foundries, but there are abundant demands for smiths'-work on a smaller scale at such an establishment as this. Beyond the smiths'-shop is another coal-store, and near this is the northern entrance to the works from Peter Street.

The northern end of this smaller court is occupied principally by one gasometer, the largest in the establishment, having a capacity of eighty thousand cubic feet: it is well placed, and has an imposing appearance, especially when raised to a height of fifty or sixty feet, as it was when we saw it. On the left or west side of the court are two of the four retort-houses—iron-roofed buildings, in which the gas is made. The arrangement of these houses we shall speak of presently, and need only say here that these two present the same striking and remarkable features which characterise the other two. In the open court of the quadrangle are indications of the same traffic and bustle which the other presents; the arrival and unloading of cargoes of coal, the heaping and sprinkling of the heated coke just brought smoking and steaming from the retort-house, &c. At various convenient places in this, as in the other quadrangle, are store-houses for coal, from whence the retorts are supplied; and in addition, wherever room could be found for them, gasometers are placed, to the number, in all, of twenty-one.

We have now noticed the principal buildings, apparatus, and general arrangements round both quadrangles of the establishment; and will next return to the one first described, and take a glance at the important building in its centre. This building is divided into various departments, such as a deputy superintendent's office, an inspector's office, a meter-room, a valve-room, two retort-houses, a coal-store, a coke-store, an engine-room, &c. The four first-mentioned rooms form a kind of additional building attached to the southern end of the remainder, and, with its motto, "STET CAPITOLIUM FULGENS," is the first object which meets the eye from the entrance. The retort-houses are built at a few feet distance from the ground, leaving space beneath for the coal and coke stores.

Whoever enters for the first time into a retort-house cannot fail to be struck with its appearance, so different from that of most other factories. The iron roof, the iron floor, the absence of windows, the absence of machinery and work-benches, the strange appearance of the walls speckled over with complicated iron-work (whose purpose is not clearly discernible), the darkness of the place, the appearance of the men—all have an aspect of strangeness. But at intervals of every hour or two, and especially at night, the visitor's attention is suddenly awakened to a startling scene going on within the building. He sees a party of men advance to one part of the side apparatus; he sees them turn the handles of what appear to be screws; he hears several explosive reports, followed by the removal of circular iron doors or covers about a foot in diameter; he sees a burst of flame from each hole whence a cover has been removed; and on going in front of one of these openings (if he have courage enough) he will perceive a mass of intensely burning coal, or rather coke, extending back to the depth of six or seven feet. Then will follow the removal, by means of rakes, of all the burning materials from each opening; then the hissing and steaming consequent on the wetting of the coke by buckets of water; and then the re-charging of the heated cavity with fresh coals. It is not until after noticing this succession of operations that a stranger can rightly understand the arrangements of such a place. They are—with slight exceptions, which we need not heed here—as follow.

Each side of the retort-house has a succession of arched recesses, each eight or ten feet high, six or seven wide, and about as many in depth. These recesses, when bricked or otherwise closed in front, form ovens or furnaces, in which fuel is burnt on a grate at the lower part. Five, six, eight, or more oblong iron vessels, each holding from two to three bushels of coals, are ranged horizontally in this oven, from front to back, so that the heat, flame, and smoke from the furnace may play around them, and make them red-hot. The outer ends of these vessels, which are the *retorts* (a name for which we have never heard a good reason assigned), are left open or closed as occasion may require; an iron door, connected with a screw, being accurately fitted to each retort. In the infancy of the gas manufacture, these retorts were made upright, as in Fig. 3; but as it was difficult to extract the coke from this form of retort, another was invented (Fig. 4), where the coals were put in at A, the coke extracted at B, and the gas emitted at C. In some establishments the upright retorts are used, but the coal is put into an open basket (Fig. 5), which enables the coke to be easily extracted. The mode, however, now generally adopted is to have horizontal retorts, whose section is one of the four represented as *a*, *b*, *c*, *d*, in Fig. 6, the form *c* being now most usually employed. The average height of the retorts is perhaps about five feet from the ground: under them is a fireplace, through which the fuel for heating the retorts is introduced; and under this again is a kind of ash-pit or shallow vessel into which the lime-water is poured for the purpose of evaporation.

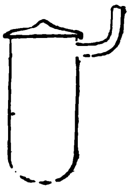
Fig. 3.

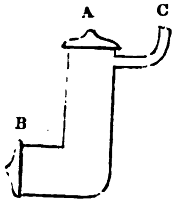

Fig. 4.

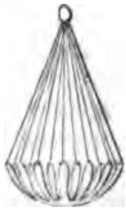
Fig. 5.

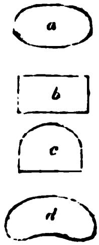

Fig. 6.

The operation then consists in this:—The empty retorts are first brought to a red heat; then a 'charge' of coals is introduced; then the cover is screwed on the end, and made air-tight by a cement of clay and lime. Thus the retorts remain for about five hours, during which the fireplace is opened every hour for the renewal of the fuel (coke at these Works) with which the retorts are heated; and at the end of this time all the gaseous and vaporisable matters having left the coal, and passed up from each retort by a pipe into the 'hydraulic main,' the 'drawing of the retorts' commences. The retort-cover is loosened by turning a screw; a slight explosion takes place when communication with the atmosphere is opened; the cover is removed by the sooty and almost fire-proof hands of the men, and the coke is drawn out by means of rakes eight or ten feet long. A kind of box, made entirely of iron, and placed upon wheels, is wheeled beneath the front of the retorts, and into it a portion of the fiery contents of each retort is drawn. The box is wheeled away, and in a few minutes volumes of steam are ascending profusely from it, the result of a plentiful supply of water, which is thrown on it for the sake of speedy cooling. The remainder of the coke is then drawn out on the iron floor of the building, and after being partially cooled by water, is removed out into the open air.

While standing within a few feet of a party of men engaged in 'drawing' a group of seven or eight retorts, apparently unharmed and unconscious of a degree of heat which would scare others, we thought of Schiller's 'Road to the Iron-foundry;' the fate intended for poor Fridolin, but experienced by the envious Robert; "the heat which seemed as though it would melt rocks;" the chuckle with which the forgemen pointed to the manner in which their lord's orders had been executed. But it is a comfort to think that neither a Robert nor a "gentle Fridolin" could be inserted in a gas-retort; nor are the stokers, though swarthy enough without, so black or so stony-hearted within as Schiller's forgemen.

The other arrangements of the retort-houses may be briefly noticed, as follows. In the upper part of every retort is an opening from which ascends a vertical pipe three or four inches in diameter. The gas, as it is formed, having no other outlet, ascends this pipe, passes thence to another pipe placed horizontally, and then enters a descending pipe, which dips into a large main fourteen or fifteen inches in diameter. This main is placed horizontally along the whole length of the retort-house, and receives all the gas from the whole range of retorts on one side, there being two mains on opposite sides of each retort-house. In these mains commences that purification of the gas which is the object of four successive processes, carried on in four distinct kinds of apparatus, viz. the hydraulic mains, the condensers, the purifiers, and the saturators. As may be readily supposed, the transference of the various products—such as gas, tar, ammoniacal liquor, &c.—from vessel to vessel, requires a large assemblage of pipes, some of which are carried underground, and others within view.

The retort-houses, such as we have just described, are four in number; two situated in the northern quadrangle, and the other two being placed parallel and contiguous in the central building of the southern quadrangle. From these we pass to a series of smaller rooms attached to the southern end of the retort-houses, and within view from the entrance-gates. One of these is the office of the deputy superintendent of the works, and the other two contain very ingenious specimens of apparatus whereby he can regulate the supply of gas at all hours of the day, calculate how much gas has been made within a certain period, ascertain the rate at which it is being manufactured at any particular time, and keep a check over the labours of the men. One of these rooms is called the 'valve-room,' and contains the apparatus for regulating the pressure and supply of the gas. To understand the use of such apparatus, it is necessary to recall to mind the striking change which occurs throughout London as evening is drawing on. The lamplighter is seen busily hastening from lamp to lamp, placing his slight ladder against the street lamp-irons, and kindling the flames which give to our streets no small share of their evening attractions; the shopkeeper begins to illuminate his wares, with one blaze if he be an humble dealer, with a dozen if his house be a 'gin-palace,' with a score or two if he sells 'unparalleled bargains' in linen-drapery; the theatres, the club-houses, the evening exhibition-rooms—all begin to display a blaze of light near about one time. Now it must be obvious that the sudden demand thus created is enormous, and it may easily be conceived that great judgment is required in adjusting the supply. In order that the gas may be propelled through the main-pipes from the factory to the remotest point supplied from the works, it is necessary to give the gas a pressure or elastic force greater than that of the atmosphere. If this pressure be too small, the lights at remote places would burn much too faintly: if too large, the flames would become so strong as to consume an inordinate quantity of gas: if the gas and the other an ingenious arrangement for showing the rate at which the gas is passing through the meter at any particular time.

The operations of a gas-factory, like those of a glass-factory, and even in a still greater degree, are interminable from the beginning to the end of the year. No cessation, even for a moment, occurs in the labours. One party of men are engaged at night; another party relieve them after an interval of twelve hours, and are employed by day; but the furnaces are always heated, the retorts always supplied with their fiercely-burning contents, the gas always undergoing the purifying processes previous to its passage into the gasometers. The number of retorts worked varies at different seasons of the year, according to the length of time between sunset and sunrise; for the gas-manufacturer is regulated, more perhaps than most other manufacturers, by the movements of the sun. But whether the number actually worked at any one time be greater or smaller, the system pursued is nearly the same. At the Westminster works the retorts are so divided into groups that some of them shall be ready for 'drawing' every hour. If we suppose, for instance, that a charge of coals remains five hours in the retort, and that the retorts are divided into five parcels or sets, one set would be filled (say) at noon, another at one o'clock, and the rest at two, three, and four o'clock respectively. Then, by five o'clock the first set of retorts are ready to be drawn; at six o'clock the second set; and so on with the others. The precise arrangements we need not enter into, but it will suffice to say that exactly as the clock strikes each successive hour, the men loosen and remove the covers of the retorts, draw out a portion of the coke into large iron boxes, draw out the rest upon the iron floor of the retort-house, throw water on the coke preparatory to its removal from the retort-house, re-charge the retorts with fresh coal, replenish the fires with a fresh supply of coke, and fit the covers—coated on their inner surface with a thick layer of lime and clay cement—firmly on the mouths of the retorts. In the intervals which elapse between the successive 'drawings,' the men are employed in pouring the lime-water into the troughs beneath the fireplaces, in placing new layers of cement on the retort-covers to be used after the next drawing, in carrying out the coke into the open air, and afterwards into the sheds or stores, in bringing coals from the coal-stores to the retort-houses, in removing the ashes which fall into the lime-water in the ash-pit, and in various other duties subsidiary to the manufacture of gas. The subsequent preparation, or rather perfecting of the gas, demands but a small amount of manual labour: it is in fact performed by the steam-engine, which pumps up the water from the well, transfers from vessel to vessel the tar and the ammoniacal liquor abstracted from the gas, and sets in rotation the arms or fans in the purifying vessels.

There is perhaps no part of the gas mechanism which requires better workmanship and more careful attention than the pipes which convey the invisible agent from the works to the places where it is consumed. However perfect may be the mode in which the gas is manufactured, however plentiful the supply, yet if the pipes are either too small or too large, if they are laid either too horizontal or too much inclined, if any of the innumerable joints are imperfectly fitted, the most serious inconvenience results. The mains vary from three inches to eighteen inches in diameter, independent of the small lateral pipes which proceed from the mains into the houses. The largest mains are placed nearest to the gas-works; the next in size are appropriated to the leading streets and thoroughfares; while the smaller are for the less important lanes and streets. Where the streets are wide, and the number of lights required large, it is usual to lay mains on both sides of the street; and the diameters of these mains are made to depend not only on the magnitude and importance of the street, but on its elevation, its distance from the works, and other circumstances. There is a circumstance attended to in laying down the mains which is perhaps not generally known. They are laid with a gradual inclination, amounting perhaps to an inch in ten or twelve yards, instead of being horizontal; and when this slope is continued for one or two hundred yards, the mains begin to ascend in a similar degree. The line of mains thus ascends and descends alternately throughout its whole length. The reason for this arrangement is, that a small deposition of fluid takes place in the mains; and this fluid, by flowing down the inclined pipes, accumulates at the lower points, where two descending lines meet: here a reservoir is formed, into which the liquid flows, and by the occasional use of a small pump from above the inconvenience is removed.

How few persons would guess the length of these underground arteries! How few would suppose that the mains, proceeding from the Westminster works alone, and ramifying through the streets at the west end of the town, would, if laid in a straight line, reach from London to Bristol; or, if combined with the 'service-pipes' which and the other an ingenious arrangement for showing the rate at which the gas is passing through the meter at any particular time.

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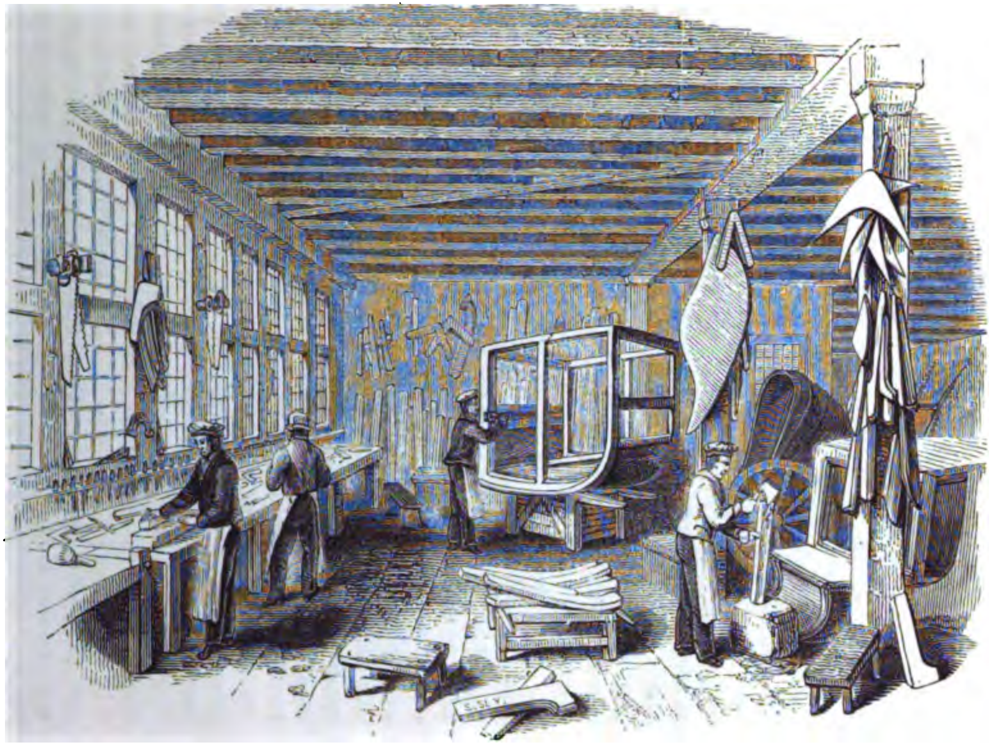
Whether or not we accept the motto used by Mr. Matthews in his work on Gas-Lighting,—

"This is an art which doth excel nature," there is abundant room for admiration and congratulation in the history and application of this light-giving agent; and the following statement, from the 'Penny Cyclopædia,' shows how extensively the advantages are now appreciated :—" Every large town in Great Britain has long had gas; the smaller towns have followed, and there is now scarcely a place in the kingdom without it. The continental nations have slowly followed our example; Paris for some years, and more recently the towns of Lyon, Marseille, Bordeaux, Nantes, Caen, Boulogne, Amiens, and several others, have adopted it. It is in use in many parts of Germany and Belgium, and St. Petersburg has a small establishment, which is rapidly increasing under the superintendence of a gentleman from one of the London works. The larger towns in the United States also burn gas; and even in the remote colony of New South Wales, the town of Sydney has introduced this valuable invention, which we have no doubt will be found there, as it has been in London, as useful in preventing nocturnal outrage as an army of watchmen."



XIX.—Coach-Makers' Loft.—Face p. 432.

Perhaps the simplest mode of viewing the construction of a coach is in reference to the materials used. These are principally timber, iron, plated metal, leather, paint, varnish, and woven materials. The main parts of a vehicle are constructed of wood, whether in relation to the body (the part in which the travellers are seated), the under framework, or the wheels. Iron is, however, used in considerable quantity, not only for the springs, but in almost every part of the vehicle, in order to enable the latter to bear the very severe strain to which it is subject. Plated metal is used principally for ornament, such as beadings, &c., in addition to its employment for handles, hinges, and various other small pieces of mechanism. Leather is used for covering the upper part of the body of the best coaches, for suspending the body in its supporting frame, for attaching the horses to the vehicle, and in a small degree for the internal trimmings of the coach. Paint and varnish are of course used for the customary purposes, in preserving and beautifying the surfaces of the wood and iron. Woven materials, such as carriage-lace, fine woollen-cloth, silk, &c., are employed in the internal decoration or 'trimming' of a coach.

It may now be asked whether these various operations are ever carried on under one roof, and by one establishment; or whether, in order to see the different processes of coach-making, it would be necessary to visit as many different tradesmen as were enumerated in a former paragraph. No one establishment makes all the various parts of a coach; and great differences exist in the extent to which the connexion of the branches is carried. Some of the smaller manufacturers merely put together the parts which have been procured ready made from other persons, while the larger firms embrace several different departments, whereby the parts of a coach are, for the most part, entirely made within one factory. We have hence thought it desirable to describe the operations of an establishment of the latter kind, such as that of Messrs. Pearce and Countze (long known as Baxter's), in Long Acre; a factory conducted on a large scale, and embracing a great number of departments.

We are not antiquarian enough to know whether Long Acre has, from the time of its formation, been a bazaar for coach-makers; but certain it is that at the present day coach-making operations form the most remarkable feature in that street. Out of about a hundred and forty houses which the street contains, more than fifty are occupied either by coach-makers, so designated, or by manufacturers of the shop, so far as regards the general arrangement. The coaches and other vehicles, in a certain stage of progress, are drawn up into this upper floor in order to be painted. In walking through this room we observe coaches undergoing the process of painting—others that of varnishing—others drying between the coats of paint or of varnish—others under the hands of the herald-painter. The 'trimming-loft,' on the same floor, is the room in which all the interior fittings of a coach are completed. Piles and rolls of morocco leather, of coach-lace, of silk, of broad-cloth, are lying around on benches and tables, and workmen are engaged in fitting the linings, cushions, fringes, and other interior decorations of private carriages.

After having quitted the main building of the factory, we cross the court-yard to the 'plater's loft.' This is a workshop in which many of the brass, steel, and plated articles belonging to a coach are either manufactured or else brought into a form fit for the coachmaker's use. It contains a 'drawing-bench,' for making the beading which is used so extensively at the edges of a coach, as well as other mechanical arrangements for working in metal.

It will thus be seen that the operations carried on within the walls of the factory are very varied, and embrace the manufacture of articles differing totally in their materials and formation. Let us now proceed somewhat more into detail.

The first thing to be done in building a coach—as in building a house or a ship—is to draw the design, to display taste and invention in the plan and proportion, so as to combine comfort with elegance to the greatest possible degree. There must be an architect for a coach as well as for a house or a ship, and he is required to possess inventive ingenuity, as well as a knowledge of geometrical forms. The working-drawing or design for a coach is sketched with chalk on a large smooth black board, and on the same scale as the vehicle to be constructed. The party for whom the coach is to be made has thus an opportunity of seeing the plan and proportions, and of suggesting alterations before practical operations are commenced. The elegance and costliness of a well-built private carriage render it quite as much an object of taste as of convenience; and thus the ingenuity of the coach-designer is constantly at work to devise improved forms and modes of arrangement in the various parts of a carriage. In addition to its elegance, too, a coach is constructed in a manner more and more conducive to the comfort of the inmates—

A door on the left-hand side of the 'show-loft' leads to the 'smith's shop,' a large square building of two stories, fitted up with every convenience for the manufacture of iron-work. Almost every particle of iron used in the construction of carriages by this firm is made within their own premises; axles, cranes, bars, stays, plates, bolts, and various other forms in which the metal is used, are made in this shop. The upper story is a 'filing and turning' shop, and the lower a 'forging' shop. The latter is provided with eight forges or furnaces, ranged conveniently round the sides; and near each forge is a gas-branch, together with anvils and the requisite utensils, for the working of the men in the evening as well as by day. All the iron and steel employed is brought in in the form of bars two or three inches wide; the former to be worked into axles, bolts, &c., and the latter into springs, which form a very important part of the fittings of a coach. When the various articles of steel and iron are brought to a certain stage in this lower shop, they are carried to the upper, where there are two or three powerful lathes for turning the metal, together with vices and benches at which men are engaged in filing and finishing the metal-work. The smiths and their assistants, from the skill and strength required of them, form a class of workmen who can command higher wages than almost any other workers in iron.

The lower floor of the smith's shop communicates with a timber-loft, and the upper floor with the show-loft, into which we now return, and proceed up another flight of stairs to the next higher story of the factory. This story is occupied as the 'coach-making loft,' and is represented in our frontispiece. All the wood-work belonging to the coaches, the wheels and some smaller portions excepted, is fashioned and put together in this workshop: it is therefore the most important part of the factory. It extends perhaps eighty or ninety feet in length, and contains all the implements and arrangements for forming the wood-work of vehicles. Coaches, chariots, cabriolets, and other forms of vehicle, are seen in various parts of the shop or loft, and in various stages of progress. Work-benches are placed round the sides on which the pieces of wood are fashioned and prepared; while the centre contains the carriages in progress.

Again we ascend to another story equal in size to the lower, and occupying the upper part of the building. This story is appropriated to two distinct workshops or lofts, the 'painting-loft' and the 'trimming-loft.' The former of these is nothing more than a large painting shop, so far as regards the general arrangement. The coaches and other vehicles, in a certain stage of progress, are drawn up into this upper floor in order to be painted. In walking through this room we observe coaches undergoing the process of painting—others that of varnishing—others drying between the coats of paint or of varnish—others under the hands of the herald-painter. The 'trimming-loft,' on the same floor, is the room in which all the interior fittings of a coach are completed. Piles and rolls of morocco leather, of coach-lace, of silk, of broad-cloth, are lying around on benches and tables, and workmen are engaged in fitting the linings, cushions, fringes, and other interior decorations of private carriages.

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The first thing to be done in building a coach—as in building a house or a ship—is to draw the design, to display taste and invention in the plan and proportion, so as to combine comfort with elegance to the greatest possible degree. There must be an architect for a coach as well as for a house or a ship, and he is required to possess inventive ingenuity, as well as a knowledge of geometrical forms. The working-drawing or design for a coach is sketched with chalk on a large smooth black board, and on the same scale as the vehicle to be constructed. The party for whom the coach is to be made has thus an opportunity of seeing the plan and proportions, and of suggesting alterations before practical operations are commenced. The elegance and costliness of a well-built private carriage render it quite as much an object of taste as of convenience; and thus the ingenuity of the coach-designer is constantly at work to devise improved forms and modes of arrangement in the various parts of a carriage. In addition to its elegance, too, a coach is constructed in a manner more and more conducive to the comfort of the inmates—

a meed of praise which we cannot always give to the prevailing form of hats and coats, for the latter often teach us that fashion is an uncomfortable tyrant.

When the form and proportions are definitely arranged and clearly sketched on the board, a plan is adopted very similar to that observed in building a ship. The pattern of a ship, as explained in another part of this volume, is drawn the full size, and a *mould* is formed of pieces of thin wood, adapted to all the chalk-marks in the sketch, and serving as guides to the shipwright in fashioning the hull of a ship. So it is with the coach-builder. He prepares a *mould* of a coach, that is, he places a series of thin pieces of wood to the chalk-marks on the board, shaping them in such a manner as to guide the saw and plane of the workmen hereafter. The chief reason for this similarity in the operation of the shipwright and the coach-builder, so far as regards the commencement of their operations, is found in the tortuous forms of the pieces of wood used in the structure. Without any further allusion to a ship, we may merely observe, that there is scarcely a right angle or a straight line throughout a coach. Curvatures of the most remarkable and complicated kind occur, which cannot be expressed in feet and inches; and thus it becomes necessary to have a type, a mould, a pattern of some kind or other, to transfer the required forms from the chalk sketch to the rough wood on which the workman is afterwards employed.

The sketch being formed, and the pattern-pieces prepared in conformity with it, the wood is selected fitted for the purpose. In the factory whose arrangements we have described above, there are two sawpits—one for cutting wood in the 'round,' and the other for 'converting.' The 'round' is the technical appellation for wood just in the form in which it is cut, before being squared, and in this form a large quantity of timber is stowed away in the factory. The operations of the sawyer, by which the trees are cut into planks, are of the usual kind, and require no particular nicety.

When the wood is cut into planks, it is 'converted' in the other pit. This term (which is also used by shipwrights in an analogous manner) relates to the cutting of the planks into the required forms by means of the pattern-pieces, and requires much more care and judgment. The rougher and larger pieces only are cut here, the smaller being shaped above-stairs. A word or two may here be said on the varieties of wood employed by the coach-builder. Ash is used very largely in the construction of coaches: the quality called 'hedge-row' ash, a tough fibrous wood, is that with which the principal parts of the frame-work of a coach are constructed: it is not liable to warp or twist, and thus becomes for many purposes a valuable kind of timber. Beech is a cheap kind of wood, never used by builders of the best coaches. Elm is employed for planking in those parts of the body of a coach requiring much strength, as also for the naves of wheels. Oak, in similar manner, is employed in various parts of coaches wherein strength and durability are required. Mahogany furnishes the material for the panels of the best coaches—those broad, smooth, and delicately curved surfaces which form the most conspicuous part of the body of a coach. Spanish mahogany, which the cabinet-maker selects as the most beautiful for his purposes, is not so useful to the coach-builder as the kind called Honduras, on account of the unfitness of its curled and twisted grain to conform to the bending which coach-panels receive. Deal and a few other kinds of timber are used to a limited extent in coaches; but ash and mahogany are the two principal kinds.

The proper timber being selected for the various parts of a coach, it is taken up to the coach-making loft, where the operations of the maker commence. It may be here stated that the term 'carriage' is used by the workman in a sense different from that commonly employed. We speak indifferently of a *coach* or a *carriage*; but the coach-builders apply the latter term only to the frame-work which lies beneath or around the body, and which serves both to support the body and to connect it with the wheels, pole, &c. Hence there are two classes of workmen employed, the one called 'body-makers,' and the other 'carriage-makers;' the one employed principally on delicate frame-work and panelling, the other on stouter masses of wood. Body-makers may be regarded as the principal artisans employed in a coach-factory. They are required to possess a practical knowledge of complicated geometrical forms, and a very accurate hand and eye. The body of a coach is first put into shape by a skeleton frame-work of ash, every piece of which is more or less curved in one direction or another, and sometimes in double curvature. The meeting edges of the various pieces of wood are seldom at right angles to the surface, and various methods of joining are thereby rendered necessary: in some parts glue, in others bolts, nails, or screws; and in others those kinds of joints known to workmen by the names of the tenon-and-mortice joint, the lap-joint, and the groove. In forming the several pieces for the body of a coach, the workman makes constant use of the pattern or mould-pieces, by which he is guided in the curvatures given to the different parts. The actual working of the wood does not differ much from the operation of a joiner; planes and the customary joining tools being alike employed by each. Not only are the skeleton pieces of the frame-work jointed together with great nicety, but equal or even still greater care is required in preparing the grooves for the reception of the mahogany panels. The panels themselves are brought to the symmetrical and elegantly curved forms which they present, partly by the plane, and partly by the united action of heat and moisture. If a thin plank be wetted on one side, and heated on the other, it will speedily become convex on the moistened side and concave on the other; and the workman is enabled to make these forms permanent.

The experience and tact requisite for this department of coach-building have the usual effect on the relation between master and workman. The rate of wages is as high, we believe, as from three to five guineas per week. Coach-body makers, indeed, rank among the highest order of London artisans: the number of first-rate workmen in that branch is limited, and does not appear likely to increase in any great degree.

The reader will then understand that the *body* of a carriage, *i. e.* that part in which the sitters are placed, is made by a class of workmen different from those who make the under part of a carriage; that the wood of which the body is principally formed (in the larger and more important factories) is principally ash and mahogany; that the workman fashions the various pieces by the aid of a pattern-board, as in the process of ship-building; that the actual process of working the wood is a superior kind of joiner's work; and that the operations are conducted in that floor of the building called the 'coach-making loft.' While the body of a coach is thus in the process of formation, the other parts are being made by other sets of workmen; the 'carriage-makers' are employed on the complicated mechanism beneath the body; the smiths are preparing the numerous pieces of iron required in various parts of the coach; and the wheelwrights are making the wheels. Perhaps we may as well introduce in this place the few observations we have to offer on the subject of wheel-making. The business of a wheelwright is totally distinct from that of a coach-builder; no establishment of the latter kind, we believe, being in the habit of making the wheels for their own coaches. But we think it desirable to put our coach upon wheels before presenting it to the reader; and shall therefore briefly describe the operations of wheel-making as carried on at the extensive manufactory of Messrs. Curll and Glover, Sutton Street, Soho.

A coach-wheel is a remarkable instance of lightness combined with strength; and not less remarkable for the accuracy of hand and eye required in its construction. As a matter of principle, a large flat circular piece of wood, with a hole in the centre, would form a wheel, and in many countries forms the only kind of wheel used at the present day; but practice shows that a much smaller quantity of material is capable of being wrought into a wheel excelling not only in elegance, but also in durability, such rude productions. The essential parts of a modern wheel are the *nave*, the *spokes*, and the *felloes*, corresponding to the centre, the radii, and the circumference of a circle. The nave is a short block of wood, usually elm, forming the middle of the wheel, and pierced with a hole to receive the axle or axle-tree. The spokes are bars of oak, radiating from the nave at equal distances one from another, and extending to equal distances from the nave. The felloes are circular segments of ash, framed on the extremities of the spokes, and joined one to another so as to form a circle. To these parts must be added the *tire*, an iron hoop which binds all the felloes closely together.

The mass of elm intended for the nave is turned to the required dimensions and shape in a lathe, and is hollowed within to receive the axle. It is then fixed in a kind of groove, with its axis horizontal; and the mortices or holes are chiselled out, for the reception of the ends of the spokes. This is a nice and difficult operation, requiring a practised eye for its proper execution, on account of the peculiar direction in which the spokes radiate from the nave of a wheel. If we stand at a short distance behind a carriage, we shall perceive that the wheels are not flat, but that they are concave on the outer surface and convex on the inner; the lower spokes are nearly in a vertical position, while the upper spokes branch out at a considerable angle from the vertical. There are various reasons for this form, some of which relate to the strength of the vehicle, some to the increase of room for the body of the coach without increasing the width of the track of the wheels, and some to the shielding of the coach from being splashed with dirt. The holes for the spokes have therefore to be chiselled in conformity with this 'dishing' of the wheel, as the conical form is called; and not only so, but half of the spokes are placed nearer to one end of the nave, and the other half to the other, for the sake of increasing the strength, and thus the holes have to be made at different parts of the nave's length.

The pieces of oak for the spokes are brought to the factory in lengths of about four feet, and are then shaped by hand to the light and elegant forms with which we are familiar. The lengths of the spokes must of course depend on the diameter of the wheel. The front wheels of a modern coach are from forty to forty-four inches in diameter; and the hind wheels from fifty to fifty-six inches. The front wheels have usually twelve spokes, and the hind wheels fourteen. A plane, the usual aid to a workman in giving a smooth surface to wood, cannot be employed in preparing the spokes, on account of the varying curvatures which they present; a small cutting tool called a 'spoke-shave' is the principal instrument employed. One end of each spoke is formed into a tenon to fit the mortice-hole in the nave; and the spokes are fixed by the operation of 'speeching,' or 'spoking,' represented in Fig. 2. The nave is placed in a kind of socket at a short

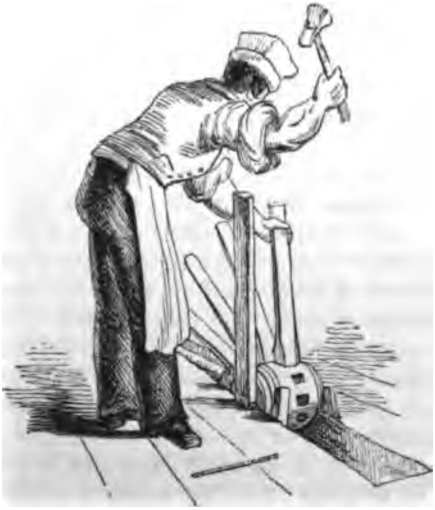

Fig. 2.

distance above the ground, in a part of the workshop where a cleft is made in the floor to receive the spokes as the nave is gradually turned round; and the spoke is then driven into the hole prepared for it, by repeated blows with a mallet. The spokes are partially shaped before being driven into the nave, and are finished afterwards. The rim of a wheel is formed of several distinct pieces called *felloes*, each felloe being long enough to receive the ends of two spokes. The ash of which they are formed is brought to the factory in short roughly-curved pieces, afterwards shaped to the proper form and dimensions by means of pattern-boards and various cutting tools. When the felloes are formed, they are fixed firmly on a low bench, and four circular holes are drilled in each piece, two to receive the ends of the spokes, which are formed into cylindrical tenons, and two for joining the felloes end to end. For the latter purposes, short cylindrical pieces of oak, about three inches long, and called 'dowels,' are made, and, being fitted to corresponding holes made in the ends of the felloes, serve to unite them one to another. Wedges are inserted when required, and the whole become thus firmly combined in the form of a wheel.

But the piecemeal manner in which the circumference of the wheel is thus made up would ill qualify it for service, were not a strengthening hoop of iron fitted on. Formerly straps of iron, called 'strakes,' were applied to the surfaces of the felloes, covering the joints; but after a time an improved method came into use, consisting in the application of a solid iron hoop, which is put on the wheel while hot, and by shrinking as it cools, forces the whole of the framing together into a firm body. The process of 'hooping' or 'tiring' a wheel is represented in Fig. 3. In an open court of the wheel-factory is a circular flat iron plate, placed in a horizontal position, with a vertical axis or stem rising from its centre. The wheel is placed down on this plate, the concave or 'dished' side downwards; the nave resting in a hole in the plate, and the wheel being fixed to the central stem by a cap and screw. Immediately adjoining this circular plate is a small furnace adapted for the reception of the hoop or tire, which has been previously welded to the required size; and when the tire is brought to a proper heat, it is taken from the furnace, and by means of iron instruments fitted to the circumference of the wheel. The diameter of the tire is such that it would not fit on the wheel while cold, but being expanded by heat, it encompasses the wheel, and gradually clings tightly to it as it gets cold. To aid in this, two men beat the tire with powerful

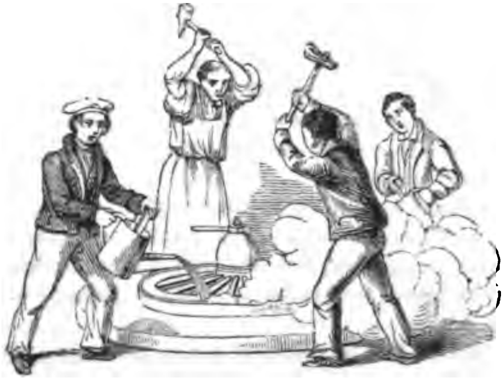

Fig. 3.

hammers, while the two others cool the iron by sprinkling it with water. Iron pins are subsequently driven through the tire and felloes, one on each side of every joint, the points being securely riveted inside the felloes. Iron hoops are also placed round the projecting parts of the nave, to enable it better to resist the strain to which it is subjected.

This brief notice will serve to convey some idea of the manufacture of the wheels of a coach. The process of painting them is one which we need not notice here; we shall therefore transfer our attention again to the coach-factory. The frame-work by which the body of a coach is connected with the wheels is, as we before observed, called the 'carriage,' and is the production of a class of workmen called 'carriage-makers.' These artisans are not required to produce such delicate work as the 'body-makers,' the masses of wood being much more heavy, and the joints fewer in number. Ash and elm are the principal kinds of wood which they use. It would be quite impossible, and, if possible, wholly uninteresting, to enumerate here all the various pieces of wood which constitute the frame-work of a carriage, some to connect the fore and aft wheels in pairs, some to connect the pairs of wheels together, some to support the body, others to support the coach-box, others again for the footman's standing-place behind, and others for the attachment of the horses to the coach. It is necessary to mention, however, one peculiarity in which a four-wheeled coach differs from many other forms of vehicle. In some coaches the body is connected with the under frame-work by pliable braces of leather attached to the springs; and in this case, the frame-work which supports the fore and hind springs is connected together by a long central piece of timber plated with iron, and called the 'perch.' An iron perch, called a 'crane-neck,' is sometimes used instead of a wooden one, and is shaped so as to enable the coach to turn somewhat more readily in a narrow street or road, an advantage which is however gained at the expense of greater weight of material.

As to the mode in which the carriage-makers proceed with their work, little need here be said. The planks and pieces of ash are roughly shaped by the saw, and are then worked to the proper contours, partly by planes, but much more by tools more or less resembling spoke-shaves.

We have before had occasion to notice the large quantity of iron-work prepared at the smith's shop in this factory. This iron is applied to various parts of a vehicle, and at different periods in the progress of the carriage towards completion. After the perch for a coach is made, and before it is fitted to the other parts of the framing, the smith takes it in hand, and fits side-plates of iron to it, for the sake of increasing the strength. In like manner many other parts of the vehicle, as soon as the wood-work is to a certain extent completed, are bound, hooped, or strengthened with iron in various different ways. All the iron for these purposes is forged out of small bars to a form nearly approaching that required, and is then either turned or filed to a regular surface. Where a perch is made entirely of iron, great muscular force is requisite in welding the different pieces into one mass. Indeed, both strength and skill are required in a coach-smith, for he has to work large and heavy bars of iron into forms containing several unequal curves, and varying greatly in thickness. There is a curious gradation of talent, and consequently of wages, observable in the operations of coach-smiths. There are the *forge-men*, the *hammer-men*, and the *vice-men*, all earning different amounts of wages. A forge-man and a hammer-man generally work together, the latter being subordinate to the former, and indeed often paid by him. The forge-man is the responsible workman: he judges of the quality of the metal, regulates the curvatures, and exercises his skill in combining elegance with strength in the various iron-fittings required for the coach. The hammer-man aids him in his work, using the sledge-hammer under the direction of the forge-man, blows the bellows, keeps up the fire, and performs other offices subordinate to the labours of the forge-man. The wages of the forge-men are often from three to five guineas a week; but those of the hammer-men are very much lower in amount. The *vice-men* are those smiths whose work is at the vice instead of the anvil. They file and finish the various pieces of iron when forged, and prepare the iron for being fixed to the wood-work of the coach.

One of the most carefully executed parts of the iron-work of a modern coach is the *axle* or *axle-tree*. The axle is the piece of wood or iron which serves as a centre for the motion of the wheels. It was formerly made wholly of wood, and was then generally termed an axle-tree; but now that metal is frequently used instead of wood, the word 'axle' is more frequently used alone. Axles used formerly to be fixed firmly in the wheels, and to revolve beneath the vehicle; but now they are more frequently so made that each wheel revolves separately on them. The first iron axles introduced were of a rude construction, but successive improvements have brought them to great perfection. The axle consists of three parts: the two *arms*, which pass into the naves of the wheels; and the *bed*, or central part, which connects the two arms together. At first, a hoop or ring was put within the hollow of the nave, to prevent the too rapid wear of the wood by the friction of the axle; but now the nave is lined with an accurately-fitted iron box, capable not only of receiving the axle with little friction, but also of containing a reservoir of lubricating oil. A modern construction, known by the manufacturers as Collinge's patent axle, is a very ingenious and complete application of this method. The box for placing within the nave of each wheel is first moulded in cast-iron, and then turned in a powerful lathe to a very beautiful degree of smoothness, especially on the inner surface, in which the axle will work. The factory to which our attention is directed contains the necessary arrangements for making these axles, as well as the other portions of iron-work. At one end of the 'filing-shop' is a large lathe, worked by one or two men at a wheel, as in Fig. 4. The tools for turning the metal, as well as the general mechanism of the lathe, require considerable strength and power. In order to make the axle work more freely in the box, the inner surface of the latter is 'case-hardened,' that is, by a peculiar action of charcoal aided by heat the surface of the iron is to a small depth converted into steel, which, being harder than the original iron, is susceptible of receiving a finer surface, and of withstanding the wearing effects of friction.

The *springs* form another and very important part of the metal-work

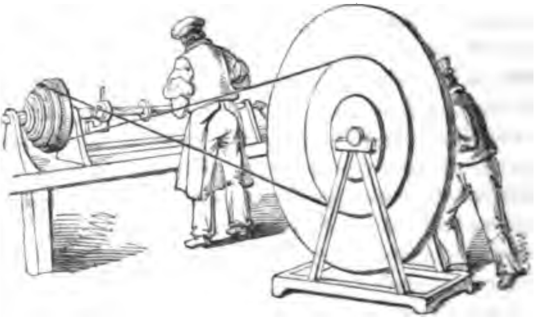

Fig. 4.

of a coach, and require a brief notice in this place. The object of a spring, whatever be the substance of which it is formed, is, by its elastic action between the wheels and the body of the coach, to diminish the concussion and irregular motion occasioned by the passage of the wheels over uneven ground. Leather might be used with a slightly elastic effect; wood is sometimes used in light one-horse vehicles; but iron or steel is the universal material for the springs of modern English coaches, and is generally applied in the form of elastic plates. The forms given to these steel springs are exceedingly varied, and contribute not a little to the general elegance of a coach. The earliest springs were formed of a single plate of steel; but in modern manufacture several plates are laid one on another, all bound in close contact, and yet free to bend independently of each other, by having the ends loose. The steel employed is prepared expressly for the purpose, and is brought by the rolling-mill to the thickness of about a quarter or three-eighths of an inch, and from one and a half to three inches wide. A compound spring, formed of several parallel plates, is hooped or bound together with an iron hoop shrunk on hot, and riveted. If it be a curved spring, the external plate is of course longer than the others, and is formed of thicker steel. All the plates are formed in a similar way. A piece of steel is cut to the required length, tapered and prepared at each end, and one or both surfaces are then 'middled,' that is, slightly hollowed by hammering. Near each end a slit is made about an inch long, in which a small rivet-head, attached to the next adjoining plate, may work. When four or more of such plates are combined, and hooped tightly in the centre, the ends are free to yield when any pressure is felt, and thus the pressure becomes equally shared by all. We may illustrate this action by the following supposition:—let a dozen laths be laid one on another, and bound or riveted tightly at both ends; they could not then be bent very far without fracture; but let them be bound only in the *centre*, and the whole will bend nearly as easily as a single lath, because the ends of each lath are free to conform to the curvature produced by the bending.

Fig. 5 represents the mode of forming one of the numerous variety of coach-springs. The assemblage of plates, after being prepared separately and laid one on another, is fixed firmly in a vice, and an iron band or hoop is hammered on, till it clasps the spring at the thickest part with great closeness. Before this is done, each plate is subjected to the action of the fire. It is first heated to a certain temperature, then plunged into water, then heated again till such a temperature is acquired as will ignite a small stick. These processes of 'hardening' and 'tempering' are requisite to the subsequent action of the spring. The plate is then 'set,' or hammered perfectly straight; then filed in

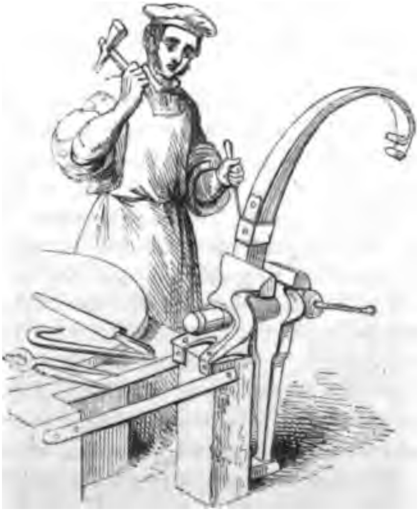

Fig. 5.

all the parts which will be visible; and the plates are in this state ready to be combined in the form of a spring. The springs are built up much in this manner, whatever be their shapes or designations. As to the technical distinctions of the 'single-elbow spring,' the 'double-elbow spring,' the 'under-spring,' the 'nut-cracker spring,' the 'C spring,' the 'S spring,' and many others, we need merely here remark that they are various forms, adapted for different kinds of carriages, some for the coach, some for the phaeton, some for the cabriolet, &c., but that all are produced by similar trains of operation.

With respect to the numerous other pieces of iron-work required in a coach, and known to the workman by the technical names of plates, loops, stays, hoops, clips, bolts, steps, treads, joints, jacks, shackles, &c., all we can say here is that they are specimens of smith's work requiring considerable skill and ingenuity.

The labours of the smith alternate, or rather are simultaneous with those of the 'body-maker' and the 'carriage-maker,' and therefore we cannot profess to follow the precise order of proceeding. At certain stages in the progress of the wood-work various pieces of iron are worked into their proper places, before other pieces of wood are connected together. This is particularly the case in 'carriage' mechanism beneath the body, in which a considerable quantity of iron is employed, the adjustment of which alternates with the work of the carriage-maker.

A remark may be applied to the 'coach-carver' similar to that applied to the 'coach-smith.' His labours are directed not to the coach as a whole, but to the several parts of it during their progress. A coach-carver must necessarily be a man of some taste, even if he only executes patterns designed by others, but much more so if he designs them himself. His operations are of two different kinds, the simplest being that of carving the beadings and mouldings of the body or carriage, and the more elaborate that of producing the foliage and ornamental tracery which add so much to the beauty of a well-built coach. In 'state-coaches' this species of decoration is profuse and very costly;* but every coach, however simple, contains more or less carving. The tools of the coach-carver resemble those of carvers in general: they are more distinguished for their excellence than for their number or their size; and the workman depends more on his own taste and invention than on any prescribed rules of proceeding. The coach-carver is indeed an artist, and as such is highly paid.

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* The carving of the present Royal State-coach of England, which was executed about eighty years ago, cost two thousand five hundred pounds!

One of the most remarkable operations in the construction of a coach is that of covering the upper part with leather; remarkable, we mean, in respect of the manual dexterity required. The panels, the quarters or upper panels, and the roof of a coach are very thickly painted, both for beauty of appearance and for durability. But the higher class of coach-builders do not trust exclusively to this external preservative; they cover the roof, and the upper part of the front, back, and sides, with leather, previous to the process of painting. It might be supposed that a hide of leather is for this purpose cut into pieces, one for the roof, one for each side, and so on; but the whole is covered with one hide, free from any joints or divisions whatever, and yet made to adhere closely to the woodwork in every part, without folds or wrinkles. The hide, which is of a large size and sound quality, is first thoroughly moistened throughout and thrown over the top of the coach, the edges hanging down on all sides. The currier then rubs or presses it down all over the roof, until it lies close and even in every part. He next proceeds to one of the sides, and in like manner rubs and scrapes the leather till all irregularities disappear. The leather is in that soft and pliable state, that it will yield to the movement of the tools, and enable the workman to fit it to every part of the coach with perfect closeness. A little consideration must show that a superfluous fold of leather will occur at each corner; yet by working it towards a central point at the back or front, the currier succeeds in erasing or pressing out all irregularities, and in producing a surface sufficiently flat and smooth for the subsequent operations of the painter. The division between the upper and lower portion of a coach is usually covered by beading of some kind or other, and the leather is trimmed or cut to this line of division. This operation of covering a coach is as important as it is curious; for if a puncture be made through the leather, and rain-water enter even in minute quantity, the surface will be uneven and disfigured.

The other portions of leather required in a coach need not much description. They consist principally of bands and straps of various kinds. The leather or hide is laid out flat on a board and cut to the required shapes by means of sharp knives. Pieces are stitched together, or buckles, loops, rings, or straps are fastened to them, in the same manner as harness-work generally is done. The workman sits at a low bench, and holding the piece of leather on which he may be at work between a pair of clams or boards, uses the awl and the sewing-twine in the same manner as the boot-maker. A horse's collar, and the general harness for a saddle-horse, do not come under the manufacturing arrangements of the coach-builder; but at the factory which we here describe, all the articles of leather required, either for the coach itself or for its attachment to the horses, are made within the walls of the building. A mode of employing leather in which much neatness and dexterity are required, is in covering the iron rails or bars fitted to gigs and phaetons, and other forms of private carriages. The leather, before being japanned or painted, is cut into strips, corresponding with the length and circumference of the rails to be covered, and is then tightly fitted on in a moistened state, the joints and angles being worked up with much nicety, and the meeting edges being stitched closely together.

A department of the coach-factory, very different from those which relate to the working of wood, iron, and leather, is that in which the painting, varnishing, and polishing are effected. The 'painter's-loft' is one in which a coach remains for a considerable period, and in which it receives no small share of its beauty of appearance. 'Coach-painting' is distinguished from ordinary house-painting by the large number of separate coats of paint laid successively one on another, and by the high degree of purity and polish given to the surface, rather than by any difference in the materials employed. The surfaces, whether of ash, oak, elm, deal, mahogany, iron, or leather, are coated so thickly with paint, that the materials themselves are effectually concealed. The paint is formed of the usual mineral colours, mixed with linseed oil and turpentine; and the varnish employed is that prepared from gum-copal, which, though slow in drying, is very durable.

The principal parts of a coach, such as the panels, the doors, the quarters, &c., receive as many as twelve or fifteen different coats of paint, each one being dried before the next following one is applied, and the whole being repeatedly smoothed or polished with rotten-stone, pumice, and similar substances. The earlier coats, as in house-painting, are termed the 'priming,' and are intended to form the foundation on which the subsequent coats are laid.

The earlier coats of paint are formed of white-lead and litharge, to which succeed many coats of white-lead and yellow-ochre. When this body of paint has been dried and smoothed, the layers of green, brown, yellow, or other selected colours are applied to those parts which are not customarily black, while black paint is laid on the parts just mentioned. A sufficient body of paint being thus laid on, the roof, the upper panels, and the sword-case (a protuberance at the back of a coach, introduced when gentlemen carried swords) are coated with several layers of black-japan, and the other parts of the coach receive six or eight coats of copal-varnish. The final process of polishing is deferred for some considerable time, to ensure the previous hardening of the varnish.

The painting of the wheels of a coach is done either by the coach-builder or the wheelwright, according to circumstances; but wherever it be effected, the process is nearly the same as for the carriage part of a vehicle. The part of the coach-painter's work which requires the largest amount of care and neatness is that of 'picking-out,' or painting fine lines, scrolls, &c. of one colour on a groundwork of a different colour. That portion of the painting which relates to the heraldic arms and crests is altogether distinct from the rest, and is the work of a higher class of artisans, called 'herald-painters,' whose services are paid for at a high rate. The herald-painter can lay no claim to comparison with the portrait-painter or the landscape-painter; but still, the accuracy of design, the neatness and clearness of outline, and the vividness of colour which he must display, require far more taste than that displayed by coach-painters, and give a higher value to his time and services.

Those to whom a sixpenny ride in an omnibus is a luxury are but little aware of the delicacy, the elegance, and the attention to personal comfort, displayed in the interior fittings of a pleasure-carriage. In one of the comedies of the last century, there is a scene in which a 'fine gentleman' laments that he has been unsuccessfully to all the mercers about town, to select for his coach a silk lining which would "suit his complexion." We do not imagine that the fine gentlemen of real life are so fastidious; but it is very certain that considerable taste is displayed in selecting not only the material, but the colour of the coach-trimmings. The principal materials employed in this manner are fine Spanish cloths, rich, plain, and embossed silks, embossed leather, richly woven lace, and horse-hair for stuffing cushions. The cloth is of the finest kind, and the silk is woven expressly for these purposes at Spitalfields. The lace employed is made sometimes of worsted, sometimes of silk, and in other instances of both combined, and it is used as a binding or edging for various parts of the interior; the finest is called 'broad-lace;' the next is termed 'pasting-lace,' about half an inch broad, and is employed to cover and hide rows of tacks; and another kind, called 'seaming-lace,' is used to cover seams and edges. The roof, sides, and various other parts of the interior of a coach are first brought to a level surface by wadding and canvas, and are then lined with cloth or silk. Cushions are covered with cloth, silk, or morocco leather, and are stuffed with horse-hair. The bottom of the coach, and the folding-steps which are shut up within the coach, are covered with carpet; and the neat appendages to the doors and windows are trimmed with cloth, lace, &c. in various ways. All these operations resemble very much those of the upholsterer; the cloth, lace, silk, and carpeting being in some places sewn and in others tacked down in their places. There is also a part of the *exterior* of a coach on which the trimmer is engaged, viz. the 'hammer-cloth.' This is a cloth covering to the coachman's seat, and is principally used for the more elegant kinds of coaches. The cloth of which it is formed is stiffened at the back, so as to enable it to fall in graceful folds. The upper and lower edges are trimmed with broad and rich lace; and the most conspicuous part of each side has usually an embroidered or chased crest. Temporary covers of oil-skin or some analogous substance are provided for the preservation of the hammer-cloth in wet weather.

A glance at the external appearance of a private carriage will show that iron is by no means the only metal employed in its construction, although it is by far the most important. Beading, plates, locks, hinges, handles, rings, buckles, crests, and ornaments of various descriptions, are made of one or other of the metals susceptible of receiving a good polish and of presenting a pleasing appearance. Brass is the principal metal employed for such purposes, or iron plated with a thin sheet of brass, where strength is required. Copper is slightly employed; so likewise is a white alloy of copper called 'white brass,' 'albata,' or 'German silver.' A considerable quantity of semi-cylindrical beading is used in various parts of a coach; and this is formed in a simple manner. An orifice is made in an iron or steel plate, the exact pattern of the cross-section of the beading; and into this opening the end of a narrow slip of sheet-metal is introduced by a workman, as in Fig. 6. This end is seized by a kind of pincers on

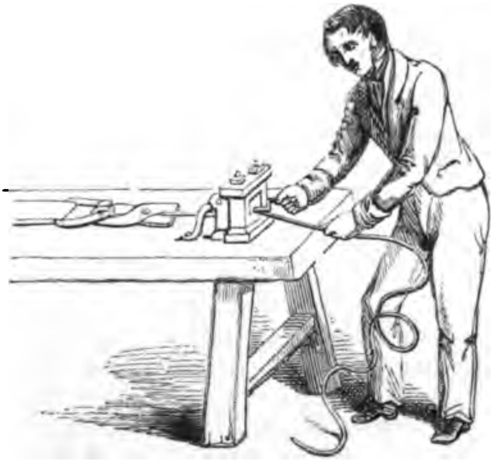
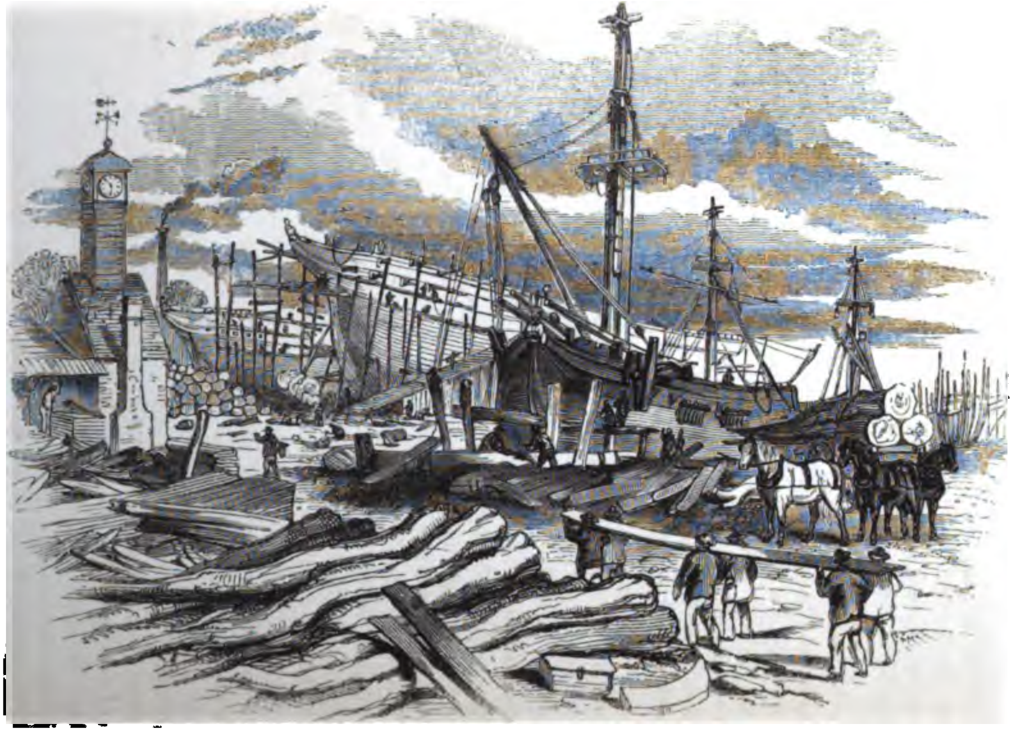


Fig. 6.

the other side, which are then drawn backwards by means of a winch at the farther end of the bench. The slip of sheet-metal is thus drawn forcibly through the pattern-hole in the plate, and acquires the required semi-cylindrical form. The metal is made very hot by the compression it undergoes. The concave side of the beading is afterwards filled in with some soft kind of metal, and is provided with points or studs for fixing it to the coach. Sometimes the beading is made of copper, in which case it is afterwards painted; sometimes of brass, if to be left exposed and bright; while for the best coaches the beading is made of a strip of sheet-copper which has had a sheet of thinner silver united firmly to it by pressure in a flatting-mill: in this case, of course, the beading is drawn with the silver side visible.

The operation of *plating*, it need perhaps hardly be observed, is that of covering some of the cheaper metals with a coating of silver, with a view to give to the article both a beauty of appearance equal to that of solid silver, and a degree of strength not possessed by silver. Many articles of coach furniture are prepared in this way, the silver being first formed into leaves, sheets, or ribands, and then firmly united to the surface of the cheaper metal by a peculiar application of heat and dexterous manipulation.

The chased ornaments, the coach-lamps, and other appendages of a well-built private carriage, we must pass over without any particular notice. A few pages form but a narrow field for the building of a coach; and we can only hope to have given a few general notions on this very diverse, complicated, and ingenious department of English manufacture.



XX.—Ship on the Stocks, building; and Ship in Dock for repairs.—Face p. 459.

XX.—A DAY AT A SHIP-YARD.

To the inhabitants of a sea-girt country, such as England, a ship must ever be an object of interest and admiration, whether regarded as the substitute—the more than substitute—for stone-walls as a defence, or as the channel whereby commerce is carried on with foreign countries. As a work of art, too, a ship has at all times and in nearly all countries called forth expressions of wonder. We may or may not, as we please, give credence to the opinion expressed in Dryden's lines :—

> " By viewing Nature, Nature's handmaid, Art,
> Makes mighty things from small beginnings grow :
> Thus fishes first to shipping did impart
> Their tail the rudder and their head the prow ;"

but certain it is that, whether fishes were or were not the first ship-draughtsmen, the art of constructing barks capable to a greater or less degree of contending with the winds and waves has been known from a very remote period.

The steps by which excellence in this art has been attained, the countries in which the art has been most fully developed, and the present state in which it exists in foreign countries, form collectively the materials for a history of naval architecture, a vast subject, into which it is not proposed here to enter. Neither does naval warfare, with its combined miseries and triumphs, fall within the scope of this article. We propose to give a description, derived from personal observation, of an establishment which ranks, we believe, at the head of the private ship-building yards in this country; to convey an idea of the general nature of the operations conducted in such establishments; and to trace, as far as the necessary limitations of popular language will admit, the order of processes by which the more important parts of a ship are constructed and put together.

The ship-yard to which we allude is that belonging to Messrs. Green, Wigrams, and Greens. The locality of the yard is somewhat remarkable, occupying, as it does, a nook on the banks of the Thames at the eastern extremity of the metropolis. We hardly know whether to place it in London or in the country, for the smoke of the one and the green fields of the other almost meet at this spot. Leaving this matter, however, as one of no importance, we will take an imaginary trip down the river to Blackwall, in order to indicate the position of this yard relatively to what is termed the 'port' of London generally.

In proceeding eastward from London Bridge, past the Customhouse, the Tower, the St. Katherine's Docks, and the London Docks, we find the northern shore of the river occupied chiefly by wharfs and by traders engaged more or less in matters connected with maritime affairs; but it is not till we arrive somewhat farther down the river that ship-building yards, properly so called, are seen. A northerly bend in the river, from nearly opposite the London Docks, constitutes that part which is called 'the Pool,' and which brings us to Limehouse. Here we find a remarkable curve in the river towards the south, and near this spot are the yards of Messrs. Curling and Young, and other ship-builders, some for ships generally, some for iron steamboats, &c. The river, for the next three miles of its course, is so tortuous that it almost encircles and encloses a tongue of land called the Isle of Dogs; a curvature which comprises within its limits Limehouse Reach, Greenwich Reach, and Blackwall Reach,—*Reach* being a term which watermen and others apply to particular parts of the river. Whether or not it is true, as Stow the annalist tells us, that one of our early kings kept his hounds in this neck of land, and that their constant barking procured for it the name of the Isle of Dogs, is a problem which we will not wait to solve, but will proceed onward to the eastern extremity of this little peninsula, passing a few smaller ship-yards in our way. Here we come to the eastern boundary of the West India Docks, which stretch nearly across the narrowest part of the Isle of Dogs; and a short distance onwards brings us to the ship-yard and docks of which we are in quest, occupying a river-frontage of a quarter or from that to a third of a mile. Beyond this we arrive at the quay or wharf in front of the eastern terminus of the London and Blackwall Railway; with the Brunswick Hotel on the left, the entrance to the East India Docks on the right, and the well-known mast-house (a tall red building of which we shall have more to say presently) in the rear, together with numerous ships in the East India Docks. As a general statement, therefore, we may say that this dock-yard occupies the principal part of the tract of ground separating the East India from the

West India Docks, opposite to that part of the Kentish coast called Bugsby's Marshes, between Greenwich and Woolwich.

With regard to the position of this yard on the land side little need be said. High Street, Poplar, leads down to the immediate neighbourhood of the yard; and the Blackwall Railway, for a part of its distance, skirts it on the north; indeed the railway passes through a portion of ground once belonging to the yard. The lofty chimney belonging to the railway is very near the mast-house, and both are separated from the yard by the railway itself.

Such, then, is the locality of these premises. The private history of commercial establishments does not in general fall within the scope of this work; but there are circumstances connected with the past history of the ship-yard under consideration, which are not only interesting in themselves, but serve to explain a certain link of connexion between the yard and the East India Docks.

The existence and active operations of this ship-building yard extend back through a period of a hundred and ninety years; for we find that during the Protectorate of Oliver Cromwell the yard was in the possession of Sir Henry Johnson, a liberal man, who seems to have contributed much to the improvement and benefit of the neighbouring hamlet of Poplar. During the Commonwealth, and the reigns of Charles II., James II., and William and Mary, Sir Henry Johnson and his son, who was also knighted, appear to have been much engaged in building the government ships; for there are records still left of about fifteen men-of-war, of from 50 to 70 guns each, built in the yard before the reign of Queen Anne. Strype, in his edition of Stow's 'Survey,' makes frequent mention of the two Sir Henry Johnsons, one or both of whom existed in his time; and also gives us a few quaint anecdotes and details relating to the yard or to its neighbourhood, which, however, are of too trifling a nature to merit quotation. The history of the yard during the early part of the last century is not very clearly to be traced; but Lysons, in his 'Environs of London,' states that the elder Sir Henry Johnson died in 1683; that the second Sir Henry succeeded to the property; and that on the marriage of the daughter of the latter to the Earl of Strafford, the possessorship of all the estates and property passed into the Strafford family.

Just a century ago, the name of Mr. Perry first appears as the owner of the yard; and in the family of the Perrys it remained for about half a century, during which period many of the men-of-war employed in the American war, and in the earlier stages of the revolutionary war, were built for the government at this yard. About the year 1789 we first hear of a commercial dock built in immediate connexion with the yard. Ever since the great fire of 1666 the port of London had remained almost unaltered with respect to docks or havens for shipping; and the merchants began to experience great inconvenience from the limited facilities afforded in this respect. Under these circumstances Mr. Perry constructed a dock which he called the 'Brunswick Dock,' adjoining the north-east boundary of his building-yard. This dock was a commodious quadrangular basin, capable of containing at one time twenty-eight East Indiamen and fifty or sixty ships of smaller burden. On the southern quay, which was eleven hundred feet in length, were cranes for landing guns and heavy stores; on the east quay were conveniences for receiving blubber from the whale-ships, as well as coppers for boiling, and warehouses for storing the whalebone; on the west quay was erected the mast-house, which still remains a conspicuous object from the river, and the purpose of which, as we shall hereafter more fully explain, was to provide a more convenient apparatus for masting ships than that which is generally employed.

Such was Perry's 'Brunswick Dock,' which appears to have been employed as well for government as for private commercial purposes; since cavalry were often embarked from the quays of this dock during the warlike transactions in the latter part of the last century. But the Brunswick Dock did not long remain private property, as the time soon approached when it became part of the East India Docks. Up to the year 1800, not one of the splendid public docks now situated on the northern bank of the river was in existence; but a spirit had sprung up and gone abroad which speedily led to the formation of these conveniences for maritime traffic. A company of West India merchants opened in the year 1802 the West India Docks, across the northern part of the Isle of Dogs, from Blackwall to Limehouse; about the same time the Corporation of London opened the City Canal, also across the Isle of Dogs; two years later another company of merchants opened the London Docks, between the Tower and Shadwell; and lastly, in 1806, a company of East India merchants opened the East India Docks, including, as a component part, the Brunswick Dock, which the Company purchased of Mr. Perry. The East India Docks consist of an import and an export dock, the latter of which was the Brunswick Dock. By this arrangement the mast-house, situated on the western quay, became likewise the property of the East India Dock Company, in whose possession it still remains.

These transactions relative to the Brunswick Dock did not disturb the regular progress of ship-building in the adjoining yard; for it appears that throughout the war the building-slips were constantly occupied with war vessels and East Indiamen. Indeed so active were the exertions at one time, that in the year 1813 no less than ten ships of war and one East Indiaman were launched from the yard within twelve months. As we have wished to touch upon these matters only so far as they elucidate a few important points in the past history of the port of London, it will be unnecessary to allude to the changes of proprietorship in the yard since the time of Mr. Perry, farther than to observe that the accession of Mr. Green, and afterwards of Sir Robert Wigram to the firm, placed the proprietorship in the families of those gentlemen, in whom it still remains.

We have to apologise to the reader for keeping him waiting so long outside the gate of the ship-yard; but we have thought that the preceding details, by explaining some of the external relations of the yard, will render what is to follow better understood. Let us, then, suppose the reader to have taken a trip on the Blackwall Railway (for the great world of London is almost too far westward to admit of the excursion on foot), and to have been set down at the Poplar station, within three or four minutes' walk of the yard. In Brunswick Street, on the eastern side of the way, we perceive the gateway leading to the yard, over and on the left of which is an old family mansion, once, we believe, the residence of Sir Henry Johnson, and, in all probability, constantly occupied since his time by one or other of the partners in the firm.

On proceeding within the entrance-gates, past a porter's lodge, the dwelling-house just alluded to lies on the left hand, while the offices and counting-houses, together with another dwelling-house, lie on the right. We soon get past these, and then find ourselves in the open yard of the premises, a large expanse of ground, occupying not less than thirteen acres. Here a multitude of objects all crowd upon the eye at once, presenting a scene of uncommon bustle and liveliness. Immediately on the right is a range of buildings apparently occupied as warehouses. Beyond these is the river, glistening in the sunshine —that is, if the weather be kind enough to admit the sun to peep through the clouds. Between the river and the eye, at short intervals, and along a great extent of shore, are seen ships of various sizes, and in all the various stages of construction, from the small steamer to the stately East Indiaman—from the mere shell of frame-timbers to the majestic ship just about to be launched; and also old ships undergoing repairs. Between these ships and the spot where we suppose ourselves to be standing near the entrance, the ground is occupied, here and there, with enormous piles of timbers, some cut to the forms required by the shipwrights, others partially sawed and hewn, and others in a rougher state. Glancing the eye round towards the left, we catch sight of a building in which a large clock serves as a monitor to all the workmen, and on the left of which is a shed where some of the timbers are cut. In the background, and towards the northern boundary of the yard, are numerous large buildings, separated from one another by tracts of ground covered in most parts by piles of wood. A third dwelling-house, occupied by one of the partners in the firm, is seen also in this direction; and the mast-house, the lofty chimney belonging to the Railway, and the shipping in the East India Docks, appear to skirt the wall of the yard.

A living scene is also presented to the eye at this spot, for on all sides are seen workmen plying the ingenious hand, and the lusty arm too, in the operation of ship-building; some standing on scaffolds at the sides of the ships; some 'converting' the timbers, that is, sawing them to the required shapes; some conveying or superintending the conveyance of timbers from one place to another; some stripping off the old copper from ships under repair; some bringing new sheets of copper to supply its place; smiths in this spot, mast-makers in that; and scores of others which we should find it no easy matter to enumerate. But when one o'clock strikes: here is a change! It is almost worth a dinner to see the hive of workmen flocking out to *their* dinner. We happened to be near the entrance at such a moment, and could not help remarking the striking change in the appearance of the yard after four or five hundred workmen had thus left it in the course of a few minutes. All became perfectly silent and lifeless, and the huge ships had a temporary respite from the beating and battering to which they had just been subject. As two o'clock approaches, straggling workmen come in by ones, twos, and threes; and by a few minutes after two, the stream of industry is pouring back again to the ships.

Such is the general aspect which the yard presents to the first view of a visitor. We will now, therefore, in company with the reader, ramble through the numerous departments of the establishment, noticing the various purposes to which the different parts of the yard are appropriated.

After entering at the outer gate, and passing the counting-house, we will turn to the right, and visit the range of workshops and store-rooms, extending from thence to the river. The first room which need be enumerated is the office of the ship-draughtsman, who is a kind of architect, employed in drawing the plans and arranging the forms and dimensions of ships, preparatory to the operations of the shipwrights. In this room are a few small models of ships, together with the necessary apparatus and drawing instruments for preparing the plans on paper. The operations of the ship-draughtsman are, as we shall explain presently, much more of a mental than a mechanical character, and, therefore, the room in which he is engaged presents little peculiar to attract our notice.

From the draughtsman's room we pass into a large and singular-looking room, called the *mould-loft*, or *moulding-loft*. It is about a hundred feet long and forty or fifty wide, rather shallow, and lighted by about twenty windows, ten on each side. The floor of this room is remarkably flat, smooth, and clean, and is chalked in every imaginable direction with lines, some straight and others curved, intersecting each other at angles of different degrees. A part of this floor, free from chalk lines, is separated from the rest by a ledge, and on this part are fixed carpenters' benches and stools, with the necessary arrangements for sawing and preparing wood-work. It is evident, at a first glance, that the chalked floor is a kind of *sanctum*, a place not to be defiled by the tread of dirty shoes. Over head is seen, resting on cross-beams, a large assemblage of pieces of thin wood, in most cases long, narrow, and curved. The operations carried on in this room are midway between that of preparing the drawing and that of actually building the ships. The purposes of the chalk marks on the floor and of the thin pieces of wood will be explained farther on.

Beneath the mould-loft we enter, among other rooms, one in which a number of boys are busily engaged in 'spinning oakum,' a process respecting which we may say a few words. When the various cables, stays, shrouds, ropes, &c., belonging to a ship have gone through their term of service, and are no longer strong enough to be used, they are cut up into pieces, and then pulled asunder, all the hempen threads being loosened and disentangled one from another. In this state the to the size of the vessel, or to the part where they are to be employed. The pieces of oak which may be selected for this purpose are first sawn to the proper length; the trenail-makers then rip each piece into a number of smaller pieces, and finally reduce them to a tolerably cylindrical shape by means of spoke-shaves, occasionally passing a ring over each piece to regulate the diameter. These trenails are generally kept for many months, to season, before they are employed in the ship. Those pieces of oak whose shape or direction of grain does not qualify them for trenails are cut into wedges, for the use of the shipwrights in various parts of their operations; and those which will not be available even as wedges are consigned to the billet-heap.

Near the spot which we have just passed are the buildings connected with the smithery. First we meet with the coal-house, filled with the fuel necessary for the operations of the smiths; and next to it the building where the swarthy sons of Vulcan are at work in an atmosphere by no means enviable. The articles made in this shop do not comprise either the ships' anchors or the chain cables, for the making of these are distinct trades, never, we believe, carried on in a private ship-building yard; but they consist of the numerous other pieces of iron-work used in the construction of a ship. The most important of these, perhaps, are the iron *knees*, which connect the beams beneath the deck of a ship with the sides, and which are a kind of bracket, with branches extending in horizontal and vertical directions, perforated for the reception of bolts. These knees are made of iron bars or plates welded together to the proper thickness and width, and fashioned to the required shape. Smaller articles, in great number and variety, are made in a similar manner, the operations being conducted almost in precisely the same way as in a common smith's shop, but on a larger scale. The fierce fires of small coal built upon the ground, the bellows for exciting the heat, the anvils, the huge sledge-hammers—some weighing nearly thirty pounds—all are seen here, on a scale which seems to rank midway between that of a common smithery and of an anchorsmith's shop. A separate shop, behind the other, is devoted to the casting of such articles as are formed of cast-metal, and to the cutting, turning, &c. of others in which neatness of appearance is required. It need hardly be observed, that these shops are black, smoky, and hot—a necessary result of the operations carried on there.

an inch to an inch and a half in diameter, are employed; these are cut to the proper lengths from bars kept in the copper warehouse. Patent alloyed metals, composed of copper and zinc, are sometimes used in parts of the ship, and these, as well as articles of copper only, are served out to the workmen from this warehouse.

Over the copper warehouse is a sail-maker's shop, where the canvas and necessary apparatus for making sails are deposited. In front of all these warerooms and shops the ground of the yard is occupied with heaps of wood, intended for different purposes, some to be employed in various departments of ship-building, and some—useless in other respects—intended as billet or firewood to be used at sea.

Proceeding onward towards the river, we fell in with some workmen making trenails, or tree-nails, and wedges. A trenail is a wooden substitute for a bolt or nail, and is regarded as a thing of much importance in ship-building. The frame-timbers of a ship, forming its skeleton, are, as we shall hereafter explain, covered inside and out with thick planks, and these planks are fastened to the timbers almost wholly by trenails, the copper bolts employed being comparatively few in number. These trenails, so far from being made of any odd pieces of waste wood, are formed of the soundest oak, whose grain is straight and regular. They vary in size from a foot and a half to three feet in length, and from one to two inches in diameter, according

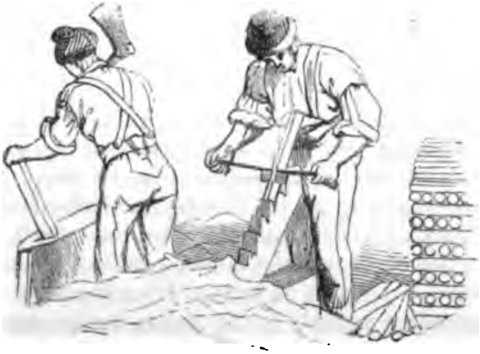


Fig. 3.

to the size of the vessel, or to the part where they are to be employed. The pieces of oak which may be selected for this purpose are first sawn to the proper length; the trenail-makers then rip each piece into a number of smaller pieces, and finally reduce them to a tolerably cylindrical shape by means of spoke-shaves, occasionally passing a ring over each piece to regulate the diameter. These trenails are generally kept for many months, to season, before they are employed in the ship. Those pieces of oak whose shape or direction of grain does not qualify them for trenails are cut into wedges, for the use of the shipwrights in various parts of their operations; and those which will not be available even as wedges are consigned to the billet-heap.

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Adjoining the smithery is an ironmonger's shop, stored with all kinds of ironmongery for the use of the yard. The circumstance generally strikes a stranger on visiting large establishments of this kind, that the whole is divided into departments as distinct from one another as if they were under different proprietors. In this yard, for instance, the copper and iron stores, however similar they may seem to be in their nature, are in two distinct departments, kept in distinct buildings, and placed under the control of different foremen, each of whom is responsible for the disposal of the property placed under his care. It is evident that, were some such plan as this not adopted, great confusion and uncertainty would prevail, involving frequently a serious misuse of materials. In the ironmonger's shop not only bolts, nails, screws, &c. are kept, but also tools, such as saws, axes, adzes, hammers, augers, shovels, &c.

By scrambling over timbers and planks, we next reach the last building in this range, appropriated to the reception and storing of rigging; and beyond this is a small wharf or shed, where articles may be landed from the water.

We have now attained the river-side, and find ourselves in view of a very pretty bend in the river, presenting Greenwich Hospital and the surrounding objects in one direction, and the course to Woolwich in the other. The river-frontage of the yard stretches nearly in a direction south-west and north-east; and as we are now at the extreme south-west corner, we will continue our ramble to the north-east extremity, keeping as close to the river as we can.

Within a few yards of the south-west corner, we came to a building-slip, where the frame-work belonging to a vessel of three or four hundred tons burden was being set up. It may perhaps be as well to explain here what is meant by a 'building-slip.' When a ship is about to be built, it is necessary to select a spot of ground from whence the vessel, when finished, may be readily passed into the water. For this purpose, a sloping tract of ground is dug or prepared, larger than the full dimensions of a ship, and at right angles to the river. This channel is level with the ground at the upper end, but is several feet beneath that level at the lower end, and open to the water. On this inclined slip of ground a ship is built; and at a certain stage in the progress the gates, which had shut out the water from below, are opened, and the ship launched into the river. Such then is the nature of a building-slip. The one to which we allude is probably about a hundred and thirty feet long by thirty broad; and on it was the rude skeleton of a vessel, formed of curved oak timbers, and supported by shores, poles, and other mechanism.

We then passed over a platform, placed across the mouth of the slip, to a kind of quay or wharf on the other side, occupied chiefly by timbers, planks, and other materials for building. This narrow strip of ground occupies the space between the slip just described and a large well-built dry dock, nearly three hundred feet long and about twenty in depth. This dock is different, both in shape and purpose, from the building-slip. It is an excavation entirely below the level of the ground from end to end, slightly inclined towards the river, and open to it at the lower end, where folding gates shut off the communication when required. Docks of this kind are not employed for building ships, but for repairing them; and the arrangements for docking are as follow:—When a ship is about to be brought into dock, a row of blocks are laid along the bottom of the dock; and the gates are opened at or about the time of low water. As the tide rises, it flows into the dock to the same level as the river; and when there is a sufficiency of water in the dock, the ship is floated into it, and guided as nearly as can be into the centre. While the tide is going down again, the water flows gradually out of the dock, and the ship sinks deeper in consequence; so that by the time low-water has again arrived, the dock is nearly emptied of water, and the keel of the vessel rests on the blocks beneath. In the mean time preparations have been making for securing the ship in her proper position, by shores, ropes, &c., so that she shall stand vertically on her keel; and at or about low-water the gates are shut, not again to be opened until the repairs of the vessel are finished. In this way a ship is dry-docked, and workmen can then descend into the dock, and examine every part of the ship's bottom down to the keel. The dry-dock of which we are now speaking is a double dock; that is, the length is sufficient to receive two large vessels at the same time. Here we saw two vessels, one an East Indiaman undergoing the process of re-coppering, and the other a smaller vessel in course of repair. In the former, tiers of stages were built round the hull of the vessel; and men were busily engaged in stripping off, by means of a kind of adze, the old and worn copper from the planking, in order to replace it with new.

Separated from this large dock by a narrow piece of ground is another dry-dock, smaller in size, but constructed in a similar manner.

Here was another East Indiaman undergoing repairs of a very extensive kind, on which a number of men were employed; some re-trenailing the outer planks, some repairing masts, &c.

Next to this dock is a building-slip, from which, about the time of our visit, the steam-vessel Princess Royal, of 700 tons burden, was launched. After a ship has been once launched, she is brought back to one of the dry-docks, where the finishing operations are conducted. A building-slip, after a launch, remains unoccupied until arrangements are made for laying down a new ship, when the ground is cleared, and the blocks laid for the keel of the new vessel. At a few yards eastward of this slip is a third dry-dock, similar in every respect to the one on the opposite side of the slip, and at that time occupied by a three-masted vessel in course of repair. But the next dock we come to is of a different kind, being a wet-dock. Here barges and boats, laden with timber and other stores for the use of the yard, enter from the Thames, and proceed to a kind of basin in the centre of the yard, round which are quays where the goods may be landed, and the water of which serves as a mast-pond in which masts are kept.

On crossing this wet-dock, we came to another slip, on which an East Indiaman was in course of building. This fine vessel, which was called the Agincourt, and which was of about a thousand tons burden, was nearly ready for launching. Shipwrights and ship-joiners were busily engaged upon it; the former driving the trenails through the planks and timbers (a process which is not done until the trenail holes, made with an auger, have been well aired and seasoned) or caulking the seams with oakum, and the latter putting up the interior fittings of the vessel.

Proceeding eastward from the Agincourt we came to a large space of ground filled with an enormous quantity of oak in the rough state. Whole trunks of trees, portions of trunks, and large branches, some of the most tortuous shapes, were heaped up to a height of twelve or fifteen feet, just in the state they left the forest. These were British oak-trees, landed on the quay of the yard, and waiting to be converted into frame-timbers, beams, &c. for ships. Adjoining this timber-quay, and farther within the yard, are sheds and sawpits wherein the trees are cut up to the desired forms and sizes.

Our progress eastward next brought us to another building-slip where was another East Indiaman, the Southampton, precisely equal and similar to the Agincourt, and, like it, advancing rapidly towards completion. This part of the yard appeared the most busy and lifelike of all, for the sawpits and sheds, and the yards belonging to them, are bounded on either side by the two slips on which the larger vessels were in course of construction.

When we come to speak of the operations of building ships, we shall illustrate many of our remarks by reference to these two vessels, which we have seen in different stages of their progress, and the fine proportions of which rendered them conspicuous objects in the yard.

Next to this was another slip, unoccupied at that time; but beyond it was one in which a steamer of nine hundred tons burden was in progress. This steamer was somewhat farther advanced than the vessel at the west extremity of the yard, having some of the planking laid on; but not so far advanced as the Agincourt and the Southampton. Beyond this slip was a fourth dry-dock, the most eastward of the whole; and in this, as in the others, was a large three-masted vessel undergoing repair. This dock is bounded by another quay, filled with oak timber in the same manner as the one between the two new slips, and contiguous to another range of sawpits. And after having passed this we arrive at the eastern extremity of the yard, separated only by a public road from Lovegrove's Brunswick Hotel.

We have now traced the whole extent of the premises on the waterside, and have next to notice the buildings in the middle and on the northern side of the yard. The yard is somewhat of a triangular shape, of which the two sides already traced are tolerably straight, while the third one is somewhat curved. In returning from the eastern extremity along this curved boundary, we come to a coal-house and a smith's shop, similar to those in the western range of buildings, and more contiguous to the vessels in the eastern part of the yard. Farther on are the buildings occupied by the boat-builders and the ship-joiners. In various parts of the space between the ships and the northern boundary of the yard are buildings devoted to several different purposes. One is the mastmaker's shop, a large building where masts, yards, bowsprits, &c. are made. A second is a steaming-house, where planks are steamed preparatory to being laid outside the timbers of a ship; the steaming is effected in square wooden trunks, about thirty feet long, provided with iron doors at one end, as in Fig. 4, which are lifted up by balance weights, and on the opening of which planks are slid into the trunks, to be afterwards exposed to the action of steam. A third building contains a range of sawpits, similar in arrangement

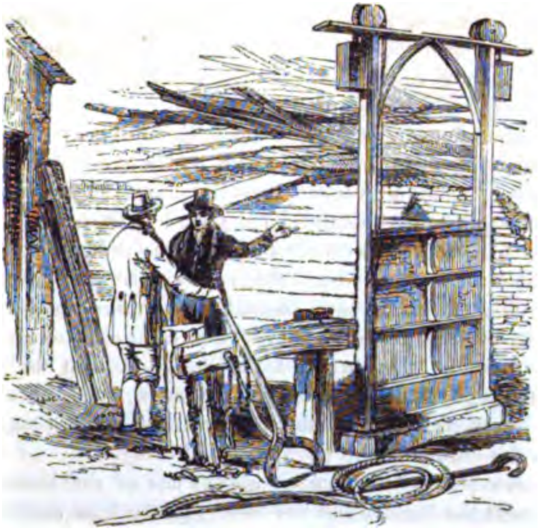


Fig. 4.

and in purpose to those already mentioned. The open spaces between these several buildings are occupied with heaps of wood—here trees waiting to be squared—there prepared timbers ready for the shipwrights—at another place planks and deals—and at another several thousand trenails placed on a stage to get seasoned. We wander between and among those heaps of wood, and at length arrive at the entrance from whence we started, having visited in our journey pretty nearly all the different parts of the yard.

Thus far have we endeavoured to convey to the reader an idea of the mode in which a large ship-building establishment is arranged. But we hope to be able to do something more than this. We propose to follow, in a cursory and popular manner, the routine of processes by which a large ship is built, so far as to show the relative dependence of one department on another. The art of ship-building involves some of the most intricate considerations which any of our manufacturing arts present; and therefore anything like an exposition of its mathematical principles is wholly foreign to our present object.

In the first place, then, let us suppose that a merchant orders a ship, intended for a particular line and kind of traffic, to be built by a ship-builder. The mode of measurement, by which an agreement is made between the parties, is rather singular, and is by no means easily understood by those who are not familiar with the general details of shipping. It is by *tonnage*, and is supposed to represent the number of tons of cargo which the proposed vessel will carry. Tonnage is estimated sometimes by bulk, but more generally by weight; a ton by bulk being equal to forty cubic feet, and a ton by weight equalling twenty cwts. There are certain formulæ employed by ship-builders, whereby the tonnage is calculated from the length, breadth, and depth of the vessel; but these formulæ seldom give the real tonnage, that is, the real amount of cargo which the vessel will carry; because, two vessels exactly equal in length, breadth, and depth—measured as those dimensions usually are—may have very different internal capacity, owing to different curvatures of the hull. A ship will sometimes carry more cargo than her 'tonnage' indicates; sometimes less; and therefore the word tonnage is to be regarded only as a rough approximation to the burden which the vessel will carry.

Still, however, the 'tonnage' is always one of the items of agreement between the builder and the owner, partly from the circumstance that when a vessel is registered, the tonnage is made to indicate its rank or class. In addition to this, the dimensions of the vessel about to be built are agreed upon, as well as the thickness and quality of the more important timbers, the thickness of the planks laid on the outside of the timbers, and other details of a more minute kind.

The specification of the vessel being thus drawn up, the ship-draughtsman commences his labours, which are of a parallel nature to those of an architect in common building. He prepares drawings of the vessel in various points of view, so as to represent the dimensions not only of the vessel itself, but also of the principal timbers composing it, and also the curvatures of those timbers.

The draughtsman having prepared these working drawings, generally on a scale of about a quarter of an inch to the foot, the next thing is to prepare a working *mould* of the ship, as large as the ship itself, in the mould-loft. The mould-loft floor is in most instances large enough to receive half the length of the intended vessel, with the whole height; and on this floor the draughtsman chalks a large number of lines, derived from the working drawings, but enlarged to the full dimensions of the vessel. These lines, generally speaking, represent the exact dimensions and curvatures of the timbers required to form the vessel; and when all the lines necessary for one-half the length of the vessel are laid down, say the bow end, another series is then laid down on the same floor, for the stern end; the two series intersecting and mingling among each other in every part. Practice enables the draughtsman to distinguish one series from the other, and thus obviate the necessity of having a mould-loft floor equal to the whole length of a large ship. When these lines, which amount to a large number, and present nothing but a confused assemblage to the eye of a stranger, are laid down, thin pieces of American deal, about three-quarters of an inch in thickness, are cut and adjusted to the curvatures of the lines, different pieces being joined end to end to produce the requisite lengths. These pieces of deal, which are called *moulds*, assist the sawyers in cutting the oak to the required sizes and curvatures for the different timbers of a ship; and there are certain marks on each piece which further this object. Let us suppose that one of the curved timbers is to be twelve feet in length, one foot thick, one foot wide, and so tortuous in form that its curvature is not circular, and none of its angles are right angles: in such case the piece of pine which forms the mould will give the curvature of the timber, while certain marks on its surface indicate the places where bevellings and angles are to be made from directions given on another board. On these principles the construction of the moulds proceeds, until a sufficient number of pieces is prepared to guide the sawyer in cutting all the timbers of the ship. For a large East Indiaman the number of moulding-pieces thus required is more than a hundred, each of which is marked and numbered in various ways.

The mould of the ship being thus prepared, the next operation is to cut up the oak and elm trunks to the proper dimensions for the various parts of the ship. This is called 'converting,' and is a process requiring great art and judgment; for the wood must be selected not only with a view to avoid waste, but also that the grain of the wood, in preparing a curved timber, may be cut crosswise as little as possible, since such a mode of cutting would greatly weaken the timber. It is therefore desirable that a crooked trunk be selected for preparing a curved timber, and that the crookedness of the one correspond as nearly as may be with the curvature of the other. The superintendence of this department devolves on a person possessing much experience and knowledge of different woods, and of their quality and relative fitness for the several timbers of a ship. When this superintendent or 'converter' has selected the proper wood, the operation of sawing proceeds nearly as in a common sawpit. The trunk of the tree is laid across a frame-work in the usual manner, and two men, one above and the other below, cut the wood by means of a long saw. The thin deal mould is used as a constant guide in cutting; the curvature, the breadth, the thickness, and the angles, all being regulated either by the mould itself or by the marks and directions chalked or painted on it. In a place where so much timber is used as in a shipbuilding yard, it might at first thought be imagined that machine-worked saws would be used; but the curvatures and angles of the timbers are so extremely varied, not only in different timbers, but also in different parts of the same timber, that the precision and regularity of machinery would be here thrown away, and indeed unavailable.

So far, then, we may suppose the principal timbers to be cut. This operation is effected in sawpits covered by sheds, of which there are three in various parts of the yard to which our attention has been directed. As the timbers are wanted, they are conveyed to the building-slip, or that spot of ground on which the construction of the ship takes place. When the timbers are thus removed, they pass from the control of the 'converter' to that of another superintendent or foreman, who is the ship-builder or ship-wright properly so called.

The building-slip is prepared for the operations in the following manner:—The ground having been cleared and made tolerably clean, a row of blocks is laid down from end to end of the slip, the length of the blocks being transverse to or across the slip. The blocks are of oak, placed one upon another, to the height of three or four feet, and secured together. These piles of blocks are ranged along the slip, at distances of about five or six feet apart, and the upper surfaces of all the blocks are so adjusted that they shall be in one straight line, but inclining slightly downwards towards the river, the inclination being about five-eighths of an inch to a foot of length. Great care is taken in laying down these blocks, as they form the support,—the work-bench, in fact,—on which the whole ship is afterwards built, the keel being laid down immediately upon the blocks.

In order to understand the succession in which the parts of a ship are put together, it is useful to notice certain points of comparison between a ship and the human skeleton. The keel is the back-bone of a ship, and the frame timbers are the ribs; the ribs forming an arched exterior to the whole of the body or hull, and the keel forming the longitudinal column to which the ribs or timbers are attached. The keel is, therefore, the principal part of the vessel, and the one above all others whose strength and security are indispensable to the safety of the vessel. From this circumstance, and from the position of the keel at the lowest part of the vessel, it constitutes the first part of a ship laid down on the slip. The keel is made of elm, and is of such length, except in small vessels, that no single tree will form it; and, therefore, two or more pieces are joined together, or, as it is termed, *scarfed*, end to end, until the required length is produced. This scarfing is a kind of overlapping, the under part of one piece and the upper part of the other, or the right side of one and the left side of the other, being cut away near the ends, and the cut or scarfed surfaces bolted together. For an East Indiaman of a thousand tons burden, such as the Agincourt and the Southampton, of which we before spoke, the keel is about a hundred and forty feet long, fourteen inches wide, and fifteen deep. For a steamer of the same burden, the length is several feet greater, since steamers are generally longer and narrower than sailing vessels of equal burden.

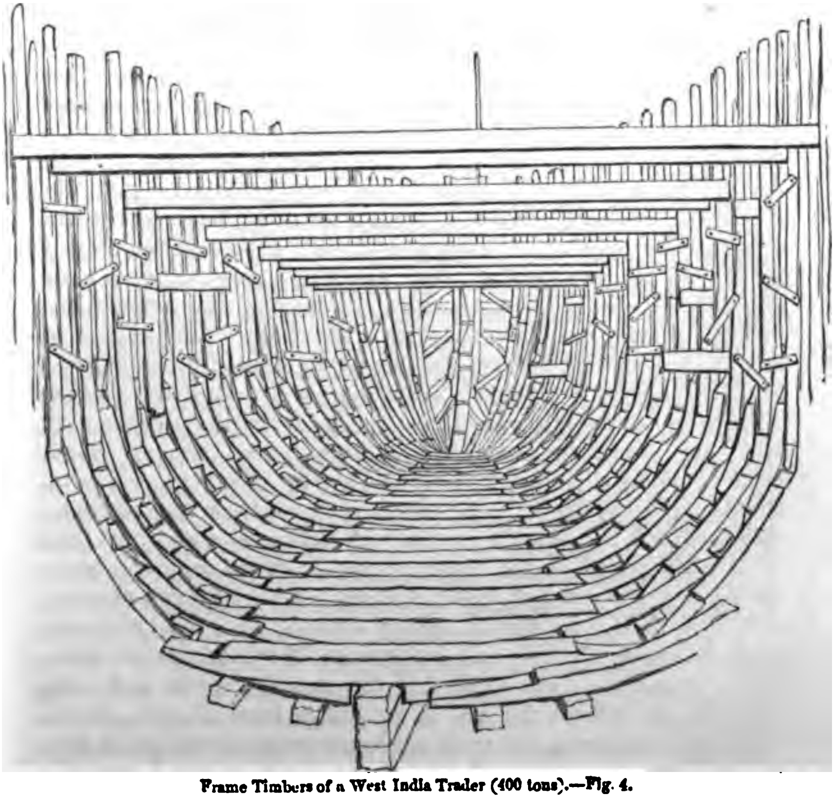
The sides and the ends of the keel are grooved and cut in various ways, to receive the different timbers and pieces of wood forming the hull of the vessel. Of these timbers, two, which form the main supports of the two ends of the vessel, are the *stem* and the *sternpost*, of which the former curves upwards from the higher end of the keel, and the latter rises almost perpendicularly from the lower end (for a ship is built with the stern end towards the river, and is consequently launched stern foremost). Both are formed of oak, and are attached to the ends of the keel in a very substantial manner. To the sternpost are attached various pieces of wood, called transoms, fashion-pieces, &c., the contour of which, when fixed in their places, is such as to give the elegantly-curved form to the hinder part of the vessel; while to the stem are attached various pieces, some of which fit it more securely to the keel, some serve to connect it with the timbers and planks afterwards to form the sides of the vessel, and others form a receptacle or support for the end of the bowsprit. The heavy pieces of timber erected thus on the two ends of the keel are hauled up to their proper positions by pulleys and tackle, and then shored up by poles from the ground, to prevent them from sinking.

Along the keel, nearly from end to end, are fixed stout timbers, called *floor-timbers*, at right angles with the length of the keel, and slightly concave on their upper surface. They are placed a few inches apart, and constitute, as the name imports, the floor of the ship. As there is a general upward curvature of the ship towards each end, the floor rises in a similar manner, and would thus leave a vacancy between the end floor-timbers and the keel; but this vacancy is filled up with solid wood, called *dead-wood*, constituting a firm foundation. The floor-timbers may be regarded as the lower part of the ribs of the ship; and above them spring up the various pieces forming the remainder or vertical parts of the ribs. No wood can be found so large, so curved, or so strong as to form the whole curved rib; and, therefore, each rib is built up of separate pieces, the general name of which is *futtocks*: thus we have the first, second, third, and perhaps fourth futtock, each being a distinct piece of timber, but all collectively forming one rib, or one 'frame of timbers.' These pieces are placed, some end to end, and others side to side, in such a manner, that the joint of two ends of timber may have a support of solid timber at its side. Various means are adopted for joining the pieces end to end, but those which are placed side by side are bolted together with bolts.

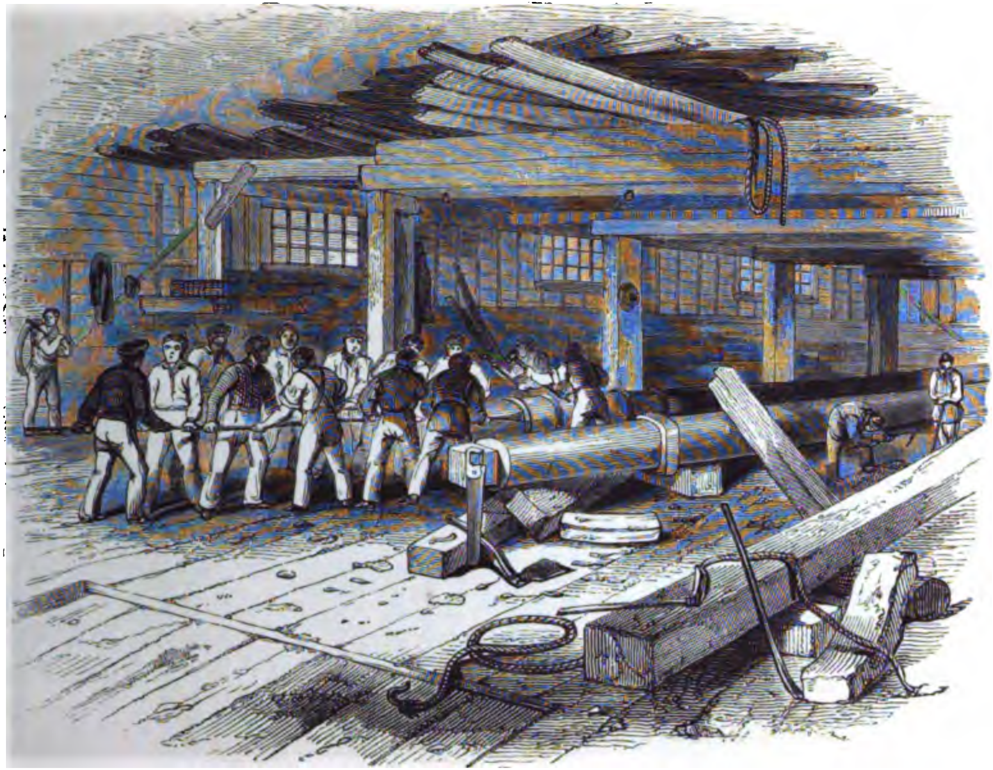
As the various futtocks curve more and more upwards, till the upper one or 'top-timber' reaches to the top of the hull of the ship, it must be evident that all the pieces forming one rib or 'frame of timbers' are very ponderous, especially if the vessel be large. The arrangements, therefore, are regulated according to the dimensions of the vessel. If it be large, the pieces, after being fitted together on the ground, are raised up singly, or perhaps two bolted together; but if it be small, three or four pieces may be bolted together on the ground, and raised as one piece. But in whatever way this part of the matter is arranged, the other operations are nearly alike. All the pieces to form one rib are adjusted and fitted to each other on the ground, and are lifted from the ground by strong tackle. The curvature and weight of the pieces is such, that, after being raised and adjusted to their places, they must be secured from falling either inwards or outwards; for the former of which purposes planks called *cross spalls* are nailed to the upper ends of the timbers, at right angles to the keel, and stretching across from one side to the other; and for the latter, planks called *rib-bands* are placed nearly horizontal round the outside of the ribs at various heights, and are shored up by poles fixed in the ground beneath.

In this manner the ribs or frames of timbers are raised one after another, from end to end of the vessel, the two halves of each frame, that is, the two parts springing from opposite sides of the keel, being raised nearly at the same time, so as to maintain the top timbers at the proper breadth across the vessel. In this stage of the proceedings, the interior shell of the vessel presents the appearance represented in the cut below. We have given an *interior* sketch, because it shows more clearly the relative position of the parts. At the bottom, just above the keel, are the floor timbers, ranged at right angles to it, and projecting some distance beyond it on either side. At the ends of these timbers are the various pieces or futtocks forming the ribs, jointed and bolted together at different parts of their heights. The ribs rise to different and irregular heights, afterwards to be adjusted; and across, from the upper part of the timbers on one side to the upper part on the other, are the spalls, the temporary wooden braces which keep the opposite sides at their proper distances.

Here, for the present, we leave the skeleton of the ship—the backbone and ribs; to finish which we will devote another visit.



Frame Timbers of a West India Trader (400 tons).—Fig. 4.



XXI.—Interior of Mast-house. Face p. 480.

come forth again to his labour, which was to draw planks and pieces of timber from one part of the yard to another." We believe that a public-house in Blackwall has received the sign of the 'Old Hob,' in honour of the horse which bore that name, and which took this very independent mode of showing his importance.

But to return. The keel, the stern-post, and the stem, form the three great supports of the frame of the vessel; the first being horizontal, the second rising from it almost perpendicularly at one end, and the third rising in a curve at the other. Among the timbers which are subsequently adjusted to the vessel are three, called the 'keelson,' the 'sternson,' and the 'stemson,' which are in some sense interior representatives of the three just named. The keelson is fixed on the floor timbers, immediately over the keel, and forms that part on which the steps or blocks of wood are placed which support the masts: it is secured down to the keel by means of bolts three feet in length, which pass entirely through both, as well as the intervening wood. The stemson and the sternson rise from the two ends of the keelson, and form internal supports to the ends of the vessel. The timbers are often strengthened within by pieces called *riders;* but in modern vessels they are frequently secured and braced one to another by diagonal iron plates, from half an inch to an inch in thickness, passing nearly from the top to the bottom of the hull, inside the vessel. Being bent round the concavity of the ship's side in an oblique direction, each piece of iron crosses several different frames of timbers, and is securely bolted to them all.

The small portion of the hull of a vessel which is seen above the level of the water presents to view a surface covered with horizontal or nearly horizontal ranges of planking; and if we could see lower down towards the keel, we should find a similar approach to a horizontal direction in the pieces of wood with which the hull is covered. Withinside, too, a similar arrangement is observable. The vertical frames of timbers of which we have been speaking do not present themselves to the eye of a person viewing a finished vessel, either within or without. The whole are covered with planking, laid in nearly horizontal rows or 'strakes.' The planks may be regarded as forming the skin with which the ribs of the ship are covered; and, indeed, the shipwrights, who almost seem to regard their ship as a living being, apply the term 'skinning' to the operation of laying on these planks; an opposite sense, it is true, to that in which we are in the habit of using this term. Nor is this skin by any means a trifling affair, for the thickness of the planks which form it varies from about three to six inches. The planks are formed of sound and durable oak, and are often nearly thirty feet in length. They are brought, while at the sawpit, as nearly to the required form as may be practicable; and are afterwards worked with the adze, to give them the proper contour. This must not be supposed to imply that the planks are hollowed or curved by the adze to the exact shape of the vessel, but that the width and thickness of adjoining planks are adjusted to each other. When a prepared plank is laid against the outside of a vessel, the convexity of the latter causes the ends of the planks to stand out several inches from it; and on the other hand, when laid on the inside, the concave surface to be in contact with the timbers, and the middle to be several inches away from them. The planks require, therefore, the aid of powerful instruments to force them close to the timbers previous to bolting; and this operation is further assisted by bringing the plank to a heated and moistened state by steam.

The parts of the planking vary in thickness, and receive distinctive names, according to the places which they occupy; but all are treated nearly in the same way—sawn, dressed with an adze, steamed, forced to the curvature of the ship, and fastened to the timbers with bolts. The trenails, which are more numerous than the bolts, are not driven in till a subsequent stage in the operations. In adjusting the planks to the ship's sides care is always taken that the adjoining ends of two planks in one row or strake shall not occur at the same part of the ship's length as a joint in the row next above or below it, a caution similar to that observed in laying the courses of bricks in a wall, or the rows of slates on a roof, and the object of which is sufficiently obvious in relation to the strength of the structure. Whoever has an opportunity of seeing the whole hull of a vessel will observe that the planking is ranged with great regularity, each strake or row diminishing in width towards the ends, to conform with the diminishing size of the vessel.

In the building of a ship matters are so arranged that many different parts are in progress simultaneously; some workmen making preparations for the beams of a vessel withinside, while others are planking the exterior, and others perhaps engaged at various parts of the head and stern. The beams are stout and well finished timbers stretching across the vessel from side to side, at intervals of a few feet, and serving not only to support the deck or decks, but also to bind the two sides of the vessel together. These beams, situated as they are at right angles to the keel, have given rise to many nautical expressions which are rather incomprehensible to general readers: thus the 'breadth of beam' is the width of a vessel; an object seen at sea in a direction at right angles with the keel, is said to be 'on the beam;' when a ship inclines very much on one side, so that her beams approach to a vertical position, she is said to be 'on her beam ends;' and many other similar phrases might be adduced.

The beams are ranged at such distances apart, that an East Indiaman of a thousand tons burden requires about thirty beneath the main deck. Each beam is usually formed of one or of three pieces, according to the dimensions of the vessel; the three pieces, in the latter case, being securely joined or scarfed together. The beams are not straight, but are curved upwards in the middle, so that their upper surfaces are convex and their lower concave; the bending being such that there is a curvature of about one inch to every yard in the length of the beam. The ends of the beams are made to rest on stout planks called clamps; but the real fastening is by means of iron brackets technically termed *knees*, bolted both to the beam and to the timbers of the ship. Besides the fastenings at the two ends of each beam, there are supporters in the middle, which are often formed of cast-iron, combining lightness of appearance with strength.

Various ledges and frames, called *partners*, *coamings*, and *carlings*, being arranged between the beams, the decks are next attended to. These divide the hull into different stories analogous to those of a house; and in the one case as in the other, the number of floors is greater in some instances than in others. Large ships of war are furnished with three entire decks, reaching from the stem to the stern; besides two shorter decks called the forecastle and the quarter-deck, the one placed at the head of the vessel, and the other towards the stern, a vacant space called the *waist* being left between them, at the middle of the ship's length. In smaller vessels of war, and in merchantmen, the decks are fewer; two whole decks and a quarter-deck being the number in an East Indiaman. The deck is generally made of Dantzig or Memel fir, and for vessels exposed to a hot climate yellow pine is sometimes employed. The deck-planks are laid side by side, lengthwise of the ship, or parallel to the keel, and vary from six to ten inches in breadth, and from two to four in thickness. They

The oakum is not placed merely at the outer edges of the crevices, but is driven in to a depth equal to the whole thickness of the plank. Sometimes the edges of the planks are chiselled away a little, in order to afford room for the entrance of the oakum; and in all cases the caulkers manage the seams in such a manner as to fill them up with a dense and compact layer of oakum, which not only answers the purpose of making the vessel tight, but also helps to consolidate and strengthen the whole ship in a very considerable degree, by making the edges of the planks bear hard against each other, so that one part cannot move or work independent of another. At the time when this caulking of the seams is going on, the planks themselves are examined, and any shakes or rents or fissures, however small, are well filled with oakum. This process being finally completed, all the caulked seams are coated, or, as it is termed, 'payed,' with hot melted pitch and rosin, by which the hempen fibres of oakum are preserved from the action of the sea-water. The *sheathing* is an exterior coating afterwards put on the bottom of the vessel; but this is a stage in the proceeding at which we have not yet arrived.

The operations withinside the vessel are, as may be supposed, much more varied than those on the outside, but they partake more and more of the nature of carpentry as the construction of the vessel advances. After the various pieces are adjusted which form the main support of the different parts of the vessel, the hull is divided into compartments accordant with the purposes for which the vessel is intended. The decks, port-holes, magazines, and berths for several hundred men in a man-of-war, and the cabins, the passenger accommodation, and luggage-room of a merchant-ship, of course require different arrangements of the interior. Supposing these matters to have been completed, we will next proceed to the important affair of *launching*, by which the vessel is borne on to the liquid element which is afterwards to form her home. Those persons who have never seen a ship launched, and who are but little acquainted with these matters, may feel it desirable to know in what stage of the building process the launching is effected. We may here mention, then, that the hull is launched before it has been sheathed or coated with copper, and also before it is fitted with masts, yards, bowsprit, rudder, sails, or ropes. There are various reasons why these several parts are more conveniently fitted after than before the launching: the height of the vessel from the ground when on the building-slip—the angle at which it slopes towards the water—

planking, and the frame-timber, but also through the inner planking; by which all three are bound well together; and the trenail-holes are bored in conformity with this arrangement. When the proper time arrives for driving in the trenails, a set of men, each provided with a large and heavy hammer, proceed to that operation. The trenail is made slightly larger than the hole into which it is to be driven, so as to bite or cling closely to the timbers; and a succession of powerful blows is requisite to urge it forward. The trenail is a little longer than the depth of the hole, and the superfluous end is taken off with a saw when the driving is finished. It is then tightened in the hole by small wedges driven in at the end.

The planking and trenailing having brought the surface of the hull to a tolerably even state, which is further assisted by a little trimming, or 'dubbing' with the adze, a process follows which is indispensable to the exclusion of water from the vessel, viz., that of *caulking*. The planks cannot be brought so close together as to make the joining impenetrable to water, and the joint is therefore filled up with oakum. We explained in a former page the manner in which threads of oakum are twisted by boys out of refuse rope, and alluded to the mode in which they are employed. A kind of chisel, called a caulking-iron, is employed to drive the threads of oakum into the seams.

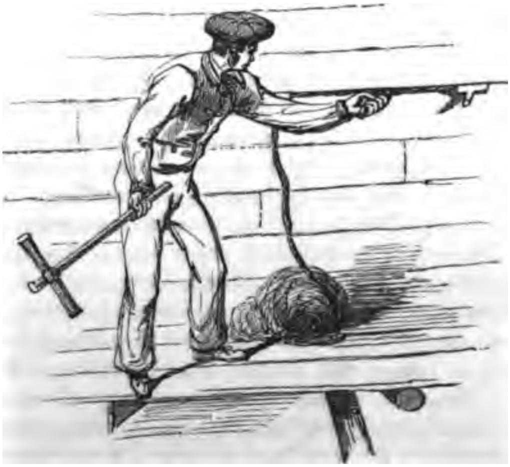


Fig. 3.

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the difficulty of getting into the vessel, &c., are some of these reasons; and with regard to the sheathing, it is deemed better to be postponed until the soundness of the naked planking has been tested by immersion in the water.

We have before explained that the ship is built on blocks, laid in regular succession along the building-slip, and so adjusted that the keel, which rests immediately on their upper surfaces, shall have an inclination of about five-eighths of an inch to the foot towards the river. These blocks form the central support beneath the vessel, during the whole progress of building; and the vessel is further supported at the side by shores, or poles, raised at various angles from the ground. As the time of launching approaches, preparations are made for removing all these lateral supports, for lifting the keel completely from the blocks, and for constructing two temporary "slippery paths" down which the vessel may slide into the river. The whole of these operations are very curious, and require great nicety and care to ensure success. Along the building-slip, on each side of the keel, and distant from it about one-sixth of the vessel's breadth, is laid an inclined platform, formed of many pieces of wood, and presenting a flat upper surface inclining downwards towards the river at an angle of about seven-eighths of an inch to the foot, and consequently more sloping than the position of the keel. The inclined plane thus formed is called the 'sliding-plank;' and it has a raised edge, or ledge, called the 'sideway,' or 'ribband,' projecting four or five inches upwards from its outer edge. The sliding-plank is placed upon supporting blocks, so as to be elevated some feet from the ground. A long timber called a 'bilge-way,' with a smooth under-surface, is laid upon this sliding-plank; and upon this timber as a base, is erected a frame-work, reaching up to the hull of the ship. This frame-work, called the 'cradle,' is formed partly of solid wood-work, filling up the whole space between the bilge-way and the hull, and partly of short poles called 'proppets,' which are erected nearly vertically, and abut against a plank fastened temporarily to the bottom of the ship. These operations are carried on on both sides of the keel, and at a few feet distant from it; and the vessel may in this state be almost said to have three keels, the real one midway between two temporary ones. At a certain stage in the building-up of these pieces, a layer of tallow, soap, and oil is placed between the sliding-plank and the bilge-way, to diminish the friction during the sliding of the latter.

than that of the other two put together; and the united length of the whole is, in the case of the mainmast, above two hundred feet. In a merchant vessel, say of a thousand tons burden, the arrangement is just the same in principle, but the dimensions smaller, the nine subordinate masts varying from about twenty to ninety feet in length, the shortest being the mizen topgallant-mast, and the longest the lower mainmast.

The masts for such vessels as the Agincourt and Southampton East Indiamen vary from about ten to twenty-eight or thirty inches in diameter; and as the latter dimensions are too great to allow the whole to be made from one tree, the mast is built up of several pieces, laid side by side in various ways, and bearing the technical names of spindles, side-trees, front-fishes, side-fishes, cheeks, cant-pieces, fillings, heel-pieces, and others equally unintelligible to general readers. The principal part of each mast, or the whole mast if the diameter be small, is made of Canadian fir, a tree which presents a remarkably straight and uniform trunk.

The 'mast-making shop,' at the yard which is the object of our visit, is a very large roofed building, above a hundred feet in length by seventy in width. It is situated close to the mast-pond in connection with the wet-dock, so that the masts can be floated in or out of the yard with great facility. The mast-makers have some tools peculiar to themselves; but the main operations bear some resemblance to those by which the timbers of a ship are fashioned. The various pieces of which a mast is built up are sawn to their proper dimensions, and fitted together by various kinds of joints, called coaking, dowelling, &c., and of which the common tenon and mortice will furnish some idea. Various cutting instruments are employed to give the rounded or convex form to the mast, when the pieces are put together; and pieces of wood are attached to its surface, to answer several purposes, when the mast is put in its place in the ship. The extent to which this building-up of a mast goes may be judged from the fact that the lower mainmast alone of an East Indiaman weighs upwards of six tons; and when lying along the floor of the mast-shop, its length of ninety feet and thickness of two and a half impress one with no mean idea of its bulk.

The various pieces of which a large mast is formed would not be permanently retained in their proper places, were there not some external band or tie employed. The band used for this purpose consists gliding of a ship to its watery dwelling. If we transfer the scene from Plymouth harbour to the river Thames, the following lines by Carrington would not be inapplicable to our present subject:—

"At last,
By genius nobly form'd, the finish'd ship
Is ready for the impressive launch. The day
Arrives, the Atlantic tide is swelling high
To place her on its bosom. O'er her decks
The streamers wave all-gallantly, around
Enlivening music floats, while myriads crowd
Where the bold vessel on her rapid plane
Sits proudly. Hark! the intrepid artizans
Remove her last supports;—a breathless pause
Holds the vast multitude;—a moment she
Remains upon her slope,—then starts,—and now
Rushing sublimely to the flashing deep,
Amid the shouts of thousands she descends;
Then rises, buoyantly, a graceful pile,
To float supinely on the blue Hamoaze."

Having launched our ship, we will next proceed to speak of the masts with which it is to be furnished. Whether the masts are placed in the vessel immediately after she is launched, or whether some other operations are immediately performed, depends on many different circumstances; but in either case, the masts have been prepared during the time that the ship has been on the stocks, the workmen employed on the one being a totally different set from those engaged on the other, and the operations being carried on in a different part of the yard. Masts, as is well known, serve as supports to the sails, and are themselves supported by ropes and tackle. The number varies in different kinds of ships: for instance, a ship properly so called is provided with three masts; a brig and a schooner are each provided with two; while one mast forms the complement for a sloop, a cutter, or a smack. But it is necessary here to remark, that a mast is not, except in small vessels, a straight piece of timber put up in one single length; it is generally formed of three stages or tiers rising one above another, each of which receives a distinctive name. Let us take for example a 74-gun ship of war. Here are three masts, the foremast, the mainmast, and the mizen-mast; and each one of these three is formed of three subordinate masts, arising one above another, of which the lowest is termed the lower mast, the next in height the top-mast, and the third the topgallant-mast. The length of the lowest is rather more than that of the other two put together; and the united length of the whole is, in the case of the mainmast, above two hundred feet. In a merchant vessel, say of a thousand tons burden, the arrangement is just the same in principle, but the dimensions smaller, the nine subordinate masts varying from about twenty to ninety feet in length, the shortest being the mizen topgallant-mast, and the longest the lower mainmast.

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The various pieces of which a large mast is formed would not be permanently retained in their proper places, were there not some external band or tie employed. The band used for this purpose consists of a series of iron hoops, ranged at intervals of four or five feet apart along the mast. These hoops are formed of iron bands about three inches in width, and three-eighths of an inch in thickness; and after being welded as nearly as may be to the girth of the mast, they are fixed on it. Each hoop—of which the lower mainmast contains about twenty, and the others a proportionate number—is in the first place heated, not to such a degree as would scorch the wood on which it is laid, but so far as to give a slight expansion to its dimensions. A small brick-built kiln is situated near the mast-shop, and in this kiln a fire is made, on which the iron hoop is laid to be heated. When the heating is effected, the hoop is taken up by means of a kind of tongs, carried to the mast-shop, put over the small end of the mast (for every mast is of smaller dimensions at one end than the other), and pushed on as far as its diameter will permit. A party of fourteen men then join their exertions to drive the hoop on as tightly as possible. Six of them grasp a long iron bar called a 'poker,' and stand in an oblique line on one side of the mast; six others hold a similar bar on the other side of the mast; and the remaining two are provided with heavy hammers. The men, thus placed, then strike the hoop with the two pokers, the end of each poker being made to strike against the edge of the hoop, and all the twelve men urging the two pokers simultaneously, by which very powerful blows are given. At the call of 'hands up,' the men direct their blows to the edge of the upper part of the hoop; while 'hands down' is a direction to them to make the blows lower down. The two men with the hammers meanwhile deal powerful blows on the surface or face of the hoop. As the hoop is driven onwards to a thicker part of the mast, it necessarily binds the wood more tightly, and this is still further effected by the contraction of the hoop as the iron becomes cold. The ultimate effect is that the hoops give an extraordinary degree of strength to the mast. Our frontispiece represents this process of 'hooping a mast.'

The *bowsprit* and the *yards* of a vessel are made by the mast-makers, and may indeed be considered as masts, so far as the mode of making is concerned. The bowsprit is a large mast which projects obliquely over the stem, to carry sail forward, in order to govern the fore part of a ship, and to counteract the force of the after-sails: it also serves to hold the stays or ropes by which the foremast is kept in its position. It generally rises at an angle of about thirty-six degrees. It very nearly equals in diameter and is about two-thirds of the length of the lower mainmast; being, in an East Indiaman, nearly sixty feet in length, and two and a half in diameter at the larger end. The *yards* are long pieces of timber suspended upon the masts, for the purpose of extending the sails: some being suspended across the masts at right angles, and called square yards; others suspended obliquely, and termed lateen yards. The number of these yards in a large ship is about twenty, and the dimensions of some of them are very considerable. The main-yard of a first-rate man-of-war is above a hundred feet in length and two feet in diameter; while the other remaining yards have various lengths down to about twenty feet, and various diameters down to three or four inches.

While hearing of these very large and ponderous masts, yards, &c., the reader may naturally inquire how they are conveyed to the ship, and lifted in their places. On this point we will now offer a brief explanation. The great difficulty is to get in the three lower masts; for the upper ones are afterwards drawn up by means of tackle with comparative ease. The lower masts are fitted in three different ways, viz., by *sheers*, by a *sheer-hulk*, or by a *masting-house*.

The *sheers* used in masting vessels are two large poles, masts, or spars, erected on the vessel whose masts are to be fixed, the lower ends resting on thick planks laid along the sides of the deck, and the upper ends crossing each other, where they are securely lashed. The point where the two spars cross is exactly over the hole where the mast is to be dropped through the deck; and the spars are retained in this position by strong ropes attached to different parts of the ship. The mast, being floated to the side of the ship, is elevated entirely above deck by means of tackle connected with the sheers; and when it is brought with the lower end immediately over the hole in the deck, it is gently lowered into its place, passing down through the entire height of the vessel, and resting on the step or block fixed to the keelson. When one of the three masts is fixed in this way, the sheers are moved to the spot where the second is to be placed, and afterwards to the third. This is the general mode of masting merchant-ships.

The *sheer-hulk* is an old man-of-war cut down to the lower deck, and fitted with an apparatus of sheers, tackle, &c., for masting the ships of the royal navy. There is a mast, a hundred and twenty feet in length, fixed in the hulk, and acting as a support to three or four stout spars or sheers which project obliquely from the side of the vessel. The tops of these sheers are at such a height, and project to such a distance from the side of the hulk, that the vessel which is to be masted can come beneath them, and be fitted with her lower masts, which are hoisted up to the requisite height by the sheers, and then lowered into the vessel. This is the general mode of masting ships of war.

The *masting-house* is a building erected expressly for the operation of masting ships. We are not aware whether there are others of the kind in this country; but the one at Blackwall, formerly spoken of as once belonging to Mr. Perry, and as being now in the possession of the East India-Dock Company, is the place at which the ships from Blackwall yard are masted. It is a square wooden building, erected on the western quay of the outward-bound dock, and having, at the top, a platform overhanging the water to the distance of several feet. The ship to be masted is floated into this dock from the Thames, and brought immediately beneath the overhanging platform. The masts are likewise floated in; and, after being hoisted up one by one by means of tackle connected with the platform, are lowered into their proper places in the ship.

Having thus spoken of the masting of a vessel (by which is usually understood the lower masts only), we will follow it back to the building-yard. We have before explained the difference between a building-slip and a dry-dock, and the manner in which a ship is brought into the latter. We will suppose it therefore to have been dry-docked, and to be ready for the process of *sheathing*, which is frequently done about this stage of the proceedings. The planks with which the timbers of a ship are covered, although the seams may be caulked with oakum and pitched, are not in a condition to be exposed to the sea without serious injury; and a casing or sheathing is therefore applied. Deal or fir plank, sheet lead, brown paper coated with tar, and sheet copper, are the substances which have been employed for this purpose; but experience has shown the last to be the best. Formerly so much grass, ooze, shells, sea-weed, &c., accumulated on and adhered to the bottom of a ship during a voyage, that the speed was impaired; and a process of breaming or graving was frequently required when she was in dock. This breaming consisted in melting the pitchy coating with which the bottom was covered, by holding kindled furze, faggots, or reeds under it, and thus loosening the matters which adhered to it, and which were subsequently scraped and brushed off. With the hope of rendering this process less frequently necessary, a sheathing of copper was proposed about eighty years ago; and the result was so satisfactory, that in 1783 the government ordered all ships belonging to the royal navy to be copper-bottomed. The practice spread from thence to the mercantile marine, and is now very generally followed.

The sheets of copper, or of an alloy of copper and zinc, for sheathing, are about four feet long by fourteen inches wide: the thickness being such that one square foot weighs from sixteen to thirty-two ounces, generally from twenty to twenty-eight. The copper is sometimes laid on the bare planking, but in other instances there is an interposed layer of paper, of felt, or of sheathing-board. The two latter are nailed on in their usual state; but if paper be employed, the sheets are first dipped in a mixture of melted tar and pitch, left to dry, and then nailed on. But whether these interposed layers are used or not, the copper-sheets are put on in a pretty uniform plan. The sheets are pierced with holes, not only all round the edges, but at intervals of three or four inches over the whole surface. Each sheet laps about one inch over the adjoining sheet, and is fastened to the ship by means of flat-headed nails, made of the same metal as the sheets. Great regularity is observed in the arrangement of the sheets, so that a certain symmetry of appearance, as well as durability, is attained.

The number of sheets of copper required for a large ship is very considerable. Nearly eight thousand square feet are required for an East Indiaman of a thousand tons burden. After two voyages to the East Indies, the coppering requires to be renewed; and the old copper is found to have lost three or four ounces of its weight in the square foot, by the action of sea-water, friction, and other causes. For recoppering a vessel, the ship is docked, and stages or platforms built round her hull, on which the workmen may stand. With instruments adapted to the purpose, the men then strip the old copper from the ship's bottom; and it is sent away to the copper-works to be again melted up into a useful form. The surface of the planking being brought tolerably smooth, and prepared in one or other of the ways alluded to above, the nailing on of the sheets of copper proceeds in the same way as for a new vessel. In a ship-yard such as that at Blackwall, where many hands are employed, and the general arrangements are on a complete scale, a vessel is frequently sent out of dock thoroughly new-coppered within two days of the time when she entered it.

We must now say a little respecting the sails and rigging of a ship. There is a superintendent either engaged in or in some measure connected with ship-yards, called the 'ship's husband,' whose office is of much importance. The term is a remarkable one, but it is in character with the general tone in which a ship is regarded by those about her. A ship, in the eyes of a seaman, is a lady: there is probably no instance in which an inanimate object is regarded with more admiration—nay, even affection—than a gallant and well-fitted ship is by her crew; and a landsman may perhaps be permitted to say that there are few more worthy of it. The 'ship's husband' is one who is well acquainted not only with the arrangement and forms of the sails and rigging, but with the general details of seamanship, and with the services which are required from every sail, yard, and rope; and his office is to see that the ship—his bride—is decked out with all the trappings necessary for her personal appearance and for her future life on the waters. Although the two facts, that sails are intended for the propulsion of a ship by wind, and that the rigging is intended chiefly for the management of these sails, may appear tolerably simple, yet the judicious arrangement of the several parts is a matter of great intricacy, and requires long study and experience.

The rigging of a ship, which is generally understood to imply the whole assemblage of ropes with which she is fitted, is of two kinds, one termed the *standing*, and the other the *running* rigging. The former term is applied to all the shrouds, stays, back-stays, and other ropes which are employed to maintain the masts and bowsprit in their proper position, and which remain pretty nearly in a constant state, whether the ship is in full sail or all the sails are furled; the latter term is applied to various ropes called braces, sheets, tacks, haliards, buntlines, &c., which are attached to different parts of the masts, yards, sails, and shrouds, and are employed principally in furling and unfurling the sails for the purposes of navigation. The whole of this rigging is made of hempen fibres, more or less saturated with tar. Those pieces of cordage which are devoted to the management of the anchors are termed *cables;* those which are employed in the general operations of rigging, and are more than an inch in circumference, are termed *ropes;* while cordage of smaller dimensions than this is generally called *lines*. But this classification is not sufficient for the purposes of the seaman; every cable, rope, and line has a distinctive name belonging to it, according to the place where or the purpose for

While describing the process of masting a vessel, we stated that it is only the lower masts and the bowsprit which are fitted by the sheers, the sheer-hulk, or the masting-house. The upper masts are not drawn up till the stage in the proceedings at which we are now arrived. The lower masts require to be secured by shrouds, &c., before the others are adjusted to them, so that the raising of the latter takes place after the rigging of the ship has been commenced. We have stated that the topmast surmounts the lower mast, and that the topgallant-mast surmounts both; but the masts are not actually joined end to end, in the usual sense of this term. A few feet below the upper end of the lower mast, a kind of platform is erected, on which the topmast rests, a little in front of the lower mast, so that the two do not actually touch in any part. This platform is called the 'top,' and is supported by various timbers termed cross-trees and tressel-trees. The topmast is drawn up to its place by means of tackle, and fixed securely to the platform, as also to a piece of timber projecting forwards from the extreme top of the lower mast. The platform serves not only as a support to the topmast, but also as a place of attachment for the shrouds by which it is upheld. When the topmast has been raised and properly secured in its place, the topgallant-mast is similarly raised, and adjusted to the upper end of the latter; and in some of the ships of war there is still a fourth mast, of very slender dimensions, called the topgallant-royal-mast, raised highest of all; but it is generally a mere prolongation of the topgallant-mast above the rigging, instead of being a separate and distinct mast. The bowsprit is, like the mast, provided with a kind of topmast or top-bowsprit, by which its effective length is increased. In this manner the vessel is gradually provided with all her masts and yards; the shrouds, stays, and other standing rigging being adjusted to their places at the same time. The yards too, or the ponderous horizontal spars by which the sails are held, are introduced into the vessel one by one, and attached to the masts to which they belong. Whoever has seen a representation of a ship with her sails furled must have remarked the vast number of ropes and blocks which connect the various parts of the masts and yards together, and which quite baffle the eye in an attempt to single them out one from another. All these ropes have certain definite offices to perform, and are placed in their respective positions by the rigger.

Meanwhile, the sail-makers have been at work, preparing their important share of the ship's fittings. We stated, while giving a to which it may be exposed. The substance thus bound round the rope is not necessarily a made-rope of smaller diameter, but is sometimes formed of old canvas, mat, plat, hide, or spun-yarn, according to circumstances. All these substances receive the common name of 'service;' and the mode of proceeding may be understood by a description of the process of 'serving' a rope with spun-yarn. The yarn might be simply twisted by hand round the rope, but the necessary tightness and compactness would not be thus attained; and a mallet is used instead. The rope being stretched out horizontally, a man provided with a mallet, and a boy holding a ball of spun-yarn, stand opposite to each other at two or three feet distance. The mallet, which has a concave groove on the side opposite to the handle, is laid on the rope, handle uppermost. Two or three turns of the spun-yarn are passed tightly round the rope, and round the body of the mallet; and while the boy passes the ball of yarn continually round the rope, the man, at the same time, and in the same direction, winds on the yarn by means of the mallet, whose handle, acting as a lever, strains every turn about the rope as firmly as possible. The yarn then appears like a screw whose threads pass almost transversely round the rope. Fig. 4. shows the position occupied by the man and boy while 'serving' a rope.

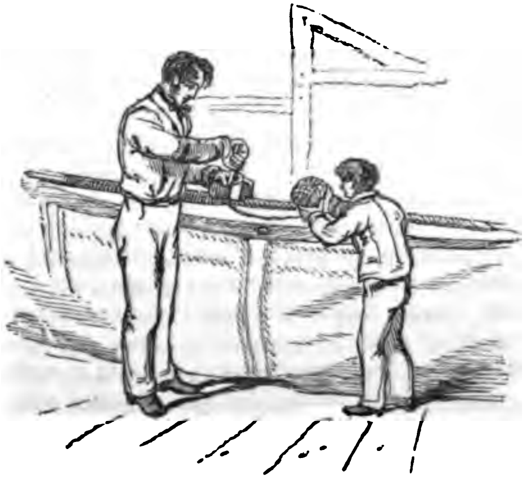

Fig. 4.

While describing the process of masting a vessel, we stated that it is only the lower masts and the bowsprit which are fitted by the sheers, the sheer-hulk, or the masting-house. The upper masts are not drawn up till the stage in the proceedings at which we are now arrived. The lower masts require to be secured by shrouds, &c., before the others are adjusted to them, so that the raising of the latter takes place after the rigging of the ship has been commenced. We have stated that the topmast surmounts the lower mast, and that the topgallant-mast surmounts both; but the masts are not actually joined end to end, in the usual sense of this term. A few feet below the upper end of the lower mast, a kind of platform is erected, on which the topmast rests, a little in front of the lower mast, so that the two do not actually touch in any part. This platform is called the 'top,' and is supported by various timbers termed cross-trees and tressel-trees. The topmast is drawn up to its place by means of tackle, and fixed securely to the platform, as also to a piece of timber projecting forwards from the extreme top of the lower mast. The platform serves not only as a support to the topmast, but also as a place of attachment for the shrouds by which it is upheld. When the topmast has been raised and properly secured in its place, the topgallant-mast is similarly raised, and adjusted to the upper end of the latter; and in some of the ships of war there is still a fourth mast, of very slender dimensions, called the topgallant-royal-mast, raised highest of all; but it is generally a mere prolongation of the topgallant-mast above the rigging, instead of being a separate and distinct mast. The bowsprit is, like the mast, provided with a kind of topmast or top-bowsprit, by which its effective length is increased. In this manner the vessel is gradually provided with all her masts and yards; the shrouds, stays, and other standing rigging being adjusted to their places at the same time. The yards too, or the ponderous horizontal spars by which the sails are held, are introduced into the vessel one by one, and attached to the masts to which they belong. Whoever has seen a representation of a ship with her sails furled must have remarked the vast number of ropes and blocks which connect the various parts of the masts and yards together, and which quite baffle the eye in an attempt to single them out one from another. All these ropes have certain definite offices to perform, and are placed in their respective positions by the rigger.

Meanwhile, the sail-makers have been at work, preparing their important share of the ship's fittings. We stated, while giving a general description of the ship-yard, that the sail-loft is situated near the mould-loft. It is an oblong apartment, sixty or seventy feet in length, and provided with tackle for stretching and drawing out the ropes which are sewn to the edges of the sails. During the principal part of the operations, the sail-makers are seated on stools, of which several are placed in different parts of the loft, each provided with little receptacles for the tools which the workman requires.

The canvas used in making sails is a very stout material, woven, either in England or Scotland, from hemp brought from Russia, and purchased in the form of rolls called 'bolts,' each bolt containing about forty yards of canvas, twenty-four inches in width. There are six or seven different qualities of canvas, according to the size and position of the sail to be made; and each quality has a particular number attached to it, and must have a certain weight per square foot: thus, in the Royal Navy, a bolt of No. 1 canvas, containing thirty-eight yards, must weigh forty-four pounds, whereas No. 7 weighs only about half as much; the intermediate numbers having intermediate weights. The canvas, though woven of stout yarn, is very regular and uniform in its appearance, and of a tolerably white tint.

The first operation is, to cut up a sufficient quantity of canvas to make a sail; and as the width of the canvas, whatever be its quality, is only two feet, a great number of breadths become necessary. The mainsail of an East Indiaman contains nearly seven hundred yards of canvas; while the whole suit of sails requires as much as nine thousand yards. Some of the sails are nearly rectangular, some triangular, some of the edges are straight, some hollowed; and the foreman has to pay especial attention to these circumstances in arranging the breadths of canvas. To cut a piece of canvas directly across, the weft or cross-thread is taken as a guide; while an oblique section is marked out by a certain deviation from the direction of the weft. The canvas is not cut by shears or scissors; but a fold being made in the required direction, previously marked with chalk or pencil, two men hold the two ends of the fold, and one of them rips up the canvas with a sharp knife.

The canvas being cut, the sail-makers then proceed to work it up. Their labour consists not only in seaming up the numerous breadths, so as to give the requisite dimensions to the sail, but also in sewing on rope, called 'bolt-rope,' round every edge of every sail: were the sail not strengthened in this manner, it would neither bear the strain of the

XXII.—A DAY AT A ROPE AND SAIL-CLOTH FACTORY.

Our next visit, like the preceding, takes us to the East end of the metropolis, where shipping and the emblems of shipping meet the eye on every side; where the shops exhibit those multifarious commodities necessary for the fitting-up of a ship, or the fitting-out of the "jolly tars," whose castle the ship is to be; where the bustle in the streets is chiefly the bustle connected with seafaring people; and where the very atmosphere seems to tell a similar tale.

The history of a ship is, as we have just seen, a complex and interesting one; and even that of a *rope* is much more curious than many readers or observers would suppose. This invaluable part of a ship's fittings is associated in the minds of some with the idea of a clumsy, dirty, tarry bundle of fibres, roughly twisted together, and coated with something altogether repugnant to the delicate fingers of the West. But we may perhaps be able to show that a large measure of inventive ingenuity has been displayed in the arrangements connected with the construction of a rope, and that—as in many an analogous case—a rough exterior envelopes much to merit our attention.

The establishment of Sir Joseph Huddart and Co., at Limehouse, which we have visited for our present object, affords great facilities, not only for this purpose, but for witnessing the manufacture of sail-cloth, to which we may also devote a brief notice.

Those who are not acquainted with Limehouse beyond the fact that it is situated somewhere in the remote East, may be informed that it is contiguous to the Thames at the North-west extremity of the Isle of Dogs; and even of those who do know the spot, some may perhaps be ignorant that there is a canal extending from the Thames at Limehouse to the River Lea. On the north bank of this canal is situated the factory which the reader is about to visit. The canal was cut seventy years ago at the expense of the city of London, to form a short com-inch and a half in width. Besides the stitching of the seams, various pieces of canvas called linings, tablings, and bands are stitched on the sail in different directions, for the sake of strengthening it at those parts which are most liable to strain. There are also many small holes to be made in some of the sails, for the reception of short pieces of cordage necessary in reefing them.

The bolt-rope which is fastened to the edge of the sails is carefully covered before it is used, to preserve it from rotting: it is first 'parcelled,' that is, encircled with narrow pieces of old canvas; then well tarred; and afterwards 'served' or bound round with a close coil of spun-yarn. The ropes are then sewn to the edges of the sail in a very careful manner; arrangements being at the same time made for the formation of numerous loops, eyes, and other mechanism necessary for the subsequent guidance of the sail. Different parts of the bolt-rope receive different names according to their position: that which binds the bottom edge is the "foot-rope;" at the top, the "head-rope;" at the sides, the "leech-rope."

Thus the operation of the sail-maker proceeds, until the whole suit of sails for a ship, generally about forty in number, are made. So well arranged are the plans by which the canvas is cut for the sails, that not more than three or four yards are actually wasted in cutting up the nine thousand yards for a large ship.

When the sails are finished, they are adjusted to their proper places in the ship by means of the ropes which govern them. The anchors, the colours, the interior fittings and furniture, and a large variety of matters which we cannot even enumerate, being also completed—the lady, in fact, being decked out in her complete attire—she is sent out of dock on the bosom of the waters, where, to use the language of Canning, she lies "majestically reposing on her own shadow," till the hour of sailing arrives.

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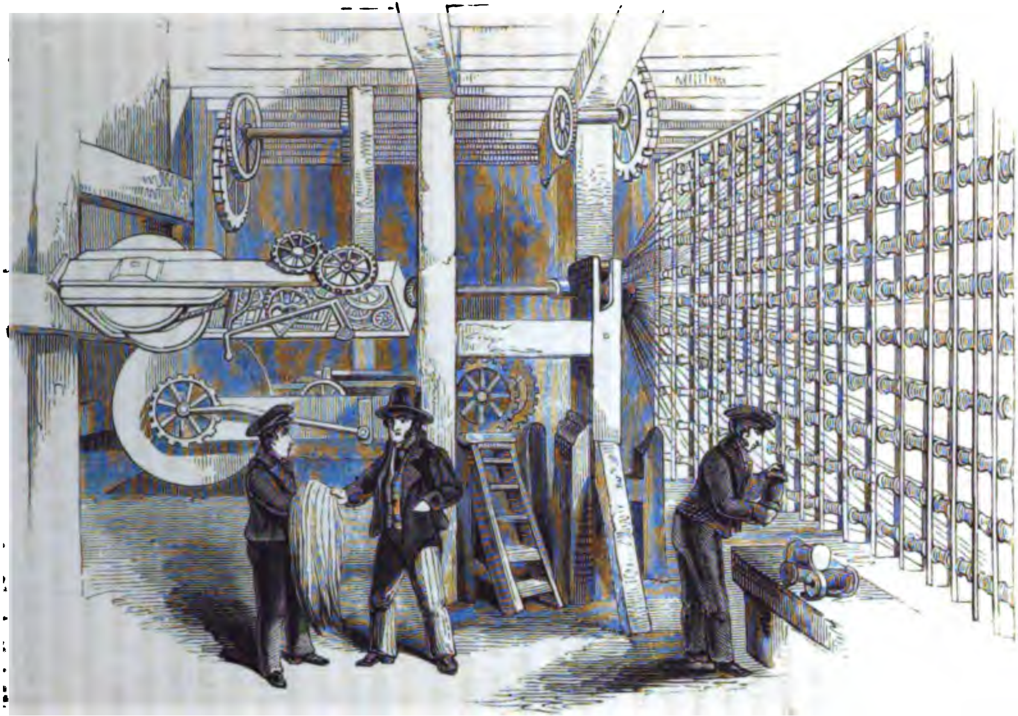


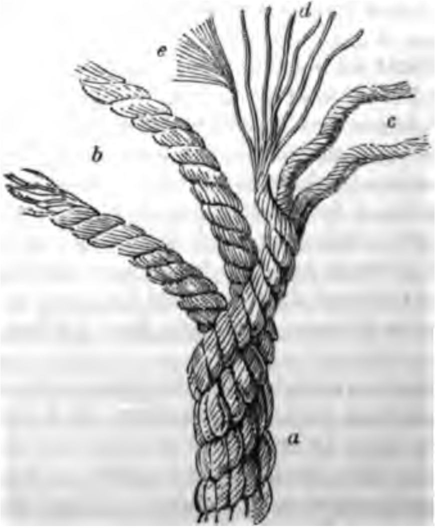
XXII.—Strand-registering Machine. Sir J. Huddart and Co.'s Rope-Works. Face p. 504.

munication between the upper course of the river Lea and the Thames at London, by avoiding the tortuous windings of Bow Creek, and of the Thames round the Isle of Dogs. We believe it has not been a very profitable speculation; but with this we have nothing here to do. At the end of a lane a few hundred feet northward of Limehouse Church, and near this canal, we enter, through a pair of folding gates, the premises of the factory.

The first object to be seen is an open plot of ground, bounded on one side by the muddy waters of this almost-deserted canal, and on the other by buildings. A second pair of entrance-gates affords access to the buildings, which consist of three parallel ranges, separated by open courts. The left of these ranges is a long, low, open, tile-roofed building, used principally as a rigging-house. In the central and right-hand ranges are the various apartments in which the manufacture is carried on, and which are very numerous. Those nearest the entrance are offices and warehouses of different kinds. In one long apartment, full of little floating hempen particles, the hatchelling, or preparation of the hemp, is being carried on. In another is the boiler and other apparatus connected with the tarring of the hempen yarn. In a separate building the barrels of tar are deposited, as a precautionary measure in case of fire. In one room are two beautiful machines, hereafter to be described, for making the earlier forms of a rope without the aid of a rope-walk. In another, iron-floored and fire-proof, is an elaborate machine for making flat-ropes.

But the most novel part of a rope-factory, to a stranger, is the apparently interminable 'walk' or avenue in which ropes are customarily made. These walks far exceed in length the workshops of most other classes of artisans; they are from six to twelve hundred feet in length, and are generally covered with a tiled roof, whether or not they are closed at the sides. At the factory under consideration there are two of these avenues, forming the northern continuations of two of the ranges of building. In one of them, boarded on one side and open on the other, the early process of rope-making is carried on, viz., that in which the hempen fibres are spun into yarns. In the other the ropes are formed from the smaller elements prepared in the spinning-walk: this walk, like the other, has an earthen floor, but it is enclosed on both sides, and has above it another long room where the yarns are prepared for twisting. Here too in the 'laying-walk,' as it is termed (*laying* being the technical term for what we should call the making or would be to lay them side by side, fastened together at intervals so as to form a bundle or skein; but as the fibres are so short, it becomes necessary, in order to obtain a rope of greater length than that of the fibres, so to twine them together that the friction between and among them shall offer an effectual resistance to any one of them being drawn out from the mass. The manner in which a hayband is formed from small blades of hay will illustrate the strength which this kind of entanglement imparts. But this is not all: the entanglement produced by twisting the fibres not only enables the rope-maker to produce cordage of any desired length, but also, by making the rope hard and compact, increases its durability, and enables it in a great measure to resist the penetration of water.

The fibres, then, are twisted round one another to form a rope; but here a curious circumstance presents itself for notice. We never see a bundle of fibres simply formed into one twist: for a rope appears to present some twists in the left-handed direction, and others in a right; and also it appears to be made up of smaller ropes. Let us analyse a 'rope's end,' and see how it is built up. We have here a representation of a small piece of cablet (a nautical name for rope formed in the same manner as, although much smaller than, a cable), which is so



Analysis of a Rope.—Fig. 2

a ton each, are separated into 'heads' or 'layers,' each containing about twelve or fourteen pounds of hemp. The tests of good quality are, that the fibres should be long, fine, and thin, smooth and glossy on the surface, free from fragments of the woody fibre of the hemp-plant, and possessed of considerable strength and toughness.

Before the rope-maker can begin to use the hempen fibres, it is necessary that they should be straight and parallel, free from dirt, and reduced as nearly as may be to an equable thickness. To effect these preparations the hemp is passed through a process which is termed 'heckling,' or 'hackling,' or 'hatchelling.' There seem to be different modes of spelling this word adopted in different factories; for writers on the subject seem to have adopted that particular one which may have been in use at the establishment which they visited; and we shall do the same, for want of a better reason. In one of the upper rooms of the factory a number of men are stationed in a row, with the simple apparatus for hatchelling. On the surface of a small bench before him, each hatcheller has a series of extremely sharp steel spikes, seventy or eighty in number, inserted point upwards, and in parallel order: this is called the hatchel. The workman, taking a 'head' or 'layer' of hemp in his hand, strikes it on the points of the hatchel, and draws it between the spikes, repeating this operation several times with each head.

The hempen fibres are not only straightened by this mode of proceeding, but the thicker ones are split by the sharp points of the wires, and all the loose fragments are made to separate and fall to the ground, Sometimes the hemp is moistened with a little whale-oil, to facilitate its progress through a hatchel; and hatchels of finer or coarser texture, that is, having more or fewer wires in a given space, are used according to the kind of cordage into which the hemp is to be made. The hatchelling-shop presents heaps of hemp, some hatchelled and some not, lying about in different directions; and the air of the room is loaded with dusty particles of hemp, struck out from the heap by the action of the hatchel.

The fibres being thus straightened and prepared, the accumulation of them into manufactured cordage commences. It is sometimes asked, "Why should the fibres be twisted; why not bind them together in a straight form?" Their limited length (three or four feet) is the chief reason why this twisting is necessary. If the fibres were of sufficient length, the most effectual mode of obtaining their united strength would be to lay them side by side, fastened together at intervals so as to form a bundle or skein; but as the fibres are so short, it becomes necessary, in order to obtain a rope of greater length than that of the fibres, so to twine them together that the friction between and among them shall offer an effectual resistance to any one of them being drawn out from the mass. The manner in which a hayband is formed from small blades of hay will illustrate the strength which this kind of entanglement imparts. But this is not all: the entanglement produced by twisting the fibres not only enables the rope-maker to produce cordage of any desired length, but also, by making the rope hard and compact, increases its durability, and enables it in a great measure to resist the penetration of water.

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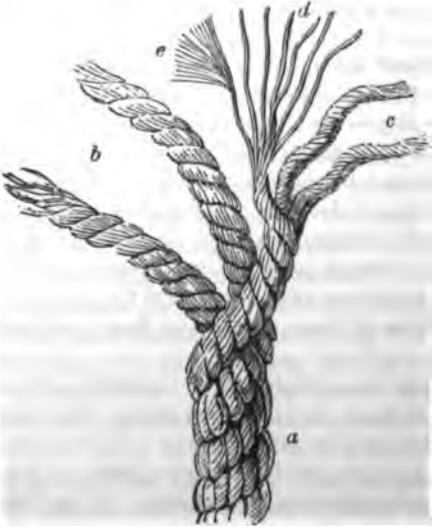

Analysis of a Rope.—Fig. 2

dissected at one end as to show the component parts. In the first place we have the cablet itself *a*, presenting the appearance with which most persons are familiar who have ever been on board a ship. By applying a little force to this, we can untwist it, and it then presents to view three smaller ropes, such as *b*, the powerful aggregation of which had formed the cablet. Each of these is known technically as a 'hawser-laid' or 'shroud-laid' rope, meaning thereby a rope formed in the same manner as a hawser, or a shroud-rope. Selecting one of these three, and applying a force to untwist it, we find that it is formed of three smaller ropes, such as *c*, which are called in the roperies 'strands;' so that there are nine of these strands in the cablet. Pursuing our analysis still further, by untwisting one of the strands, we find that it is composed of a considerable number of small strings, such as *d*, all about equal in thickness: these are called 'yarns;' and if we untwist one of the yarns, we arrive finally at the hempen fibres themselves, represented at *e*.

It thus appears, that instead of twisting many hundreds or thousands of hempen fibres one round another, there are successive groups formed, each one augmenting the thickness of the rope previously produced: thus many *fibres* are spun into a *yarn*, many yarns into a *strand*, three strands into a *rope*, and three of these latter into a *cable* or *cablet*. Now for the reason of this. If a cable were formed at once of the individual yarns, twisted one round another, the outer layer would be necessarily exposed to more stress than the internal yarns, since the latter lie at less distances from the centre of the rope. When twisted together, the outer yarns would form a spiral of a number of turns round the included yarns, being thereby much shortened; whilst the inner yarns would take only the same number of turns round a reduced axis, being thereby less shortened than the former; from whence it would follow that the outer yarns only would be in full tension, while those within would be more or less coiled up according to their proximity to the centre of the rope. The ultimate result would be, that the outer yarns would break long before the inner ones had borne their fair share of the strain to which the rope might be exposed. It is probable that in the primitive times of rope-making this rude method was adopted, and that it was gradually abandoned when the makers found that the yarns would bear more equally by building up the rope as it were piecemeal, and giving to each successive accumulation a twist in a direction contrary to that of its component parts.

'tarred-rope.' When a rope is to be used in the open air, but under cover, it is left in the 'white' state; that is, it is not coated with tar or any other substance. But when it is exposed to the action of water, a coating of some composition is found necessary to enable the hemp to resist the rotting influence of the water, and tar is the substance almost universally used for this purpose. As regards actual strength, an untarred rope is the stronger of the two; but this is more than counterbalanced by the action of water on the hempen fibre. Propositions have at several times been made to substitute for tar some other composition; but we have here only to speak of the method actually employed.

The hemp is tarred (if tarred at all) after it has been spun into yarn, but before the yarns are twisted into strands. The reels of yarn are first 'warped' into a 'haul,' that is, the yarns are unwound from the reel, stretched out straight and parallel, and assembled together in a large group called a 'haul.' This haul frequently consists of between three and four hundred yarns, each a hundred yards in length; and in this state the hemp is tarred. In one of the buildings of the factory is a huge copper for containing melted tar. The haul dips into the tar (which is heated to a temperature found to be the best for penetrating to the heart of every yarn), and is then dragged through a grip or gauge, which compresses the yarns so much as to force the tar into every part of the haul, and at the same time squeeze out the superfluous portion. By the aid of a capstan the haul is drawn gradually forward, until the whole has passed through the tar-kettle.

The tarred haul then passes into an upper building of the factory, called the 'winding-loft,' where it is wound, by the aid of a simple but ingenious machine, upon bobbins about a foot high, each bobbin being made to contain about twenty pounds of yarn.

The state to which we have now traced our rope is that of a yarn, say one-sixth or one-eighth of an inch in diameter, rough, somewhat uneven, and of a brown colour. This yarn we have next to trace into the form of a 'strand.' As the thickness of yarns is classified according to the number of them required for a three-inch rope, so does the number of yarns combined to form a strand depend altogether on the thickness of rope to be formed. It is this which forms the chief point of difference between different ropes, for the yarns do not vary very greatly in thickness. In the piece of cablet of which we have given a sketch there are only seven or eight yarns in a strand: in a cable twelve inches in circumference there are eighty yarns to a strand; and spinner walks backwards, the rapidity at which the hook rotates, and the number of fibres drawn out by each movement of the left hand, are all concerned in determining the thickness of the yarn produced. The men by long practice are enabled so to proportion their movements as to produce any given length of yarn from a given weight of hemp.

In this way the spinners continue to work for hours together, walking backwards while they are spinning the yarn, and forward while the yarn is being wound on a reel. Along the whole length of the 'walk' there are at intervals transverse beams overhead, into which hooks are driven; and on these hooks the yarns are suspended when it is necessary to prevent them from trailing on the ground. Each spinner can make about a thousand feet of yarn in twelve minutes. The number of fibres forming each yarn is never reckoned among the rope-makers' calculations; but the yarn is estimated by the *weight* of hemp contained in a given length: thus, a rope three inches in circumference being taken as a standard, and this divided into three strands, the yarns are numbered 18, 20, 25, 30, or 40, according to the number required to form one of these strands, and each of these has a definite weight for a given length. Taking as an example a three-inch rope, of which each strand is to contain twenty yarns, one hundred and sixty fathoms (nine hundred and sixty feet) of the yarn must weigh three pounds and a half. All these are matters which the fingers of the spinner regulate almost intuitively: he does not stop to work out 'multiplication sums,' but produces a 'No. 20' or a 'No. 25' yarn by manipulative adjustments, of which he himself could probably give very little explanation.

We may mention here that nearly all the spinning and twisting concerned in rope-making are or have been more or less effected by machinery in different factories: but in principle the result is precisely the same whether the hooks be made to rotate by a hand-winch or by a steam-engine applied to a larger apparatus; and we have therefore spoken of the spinning in its simplest and most easily understood form. When a 'spinning-walk' is in full operation, there are twelve spinners at different parts of its length, in three groups, each group being distant three or four hundred feet from the next adjoining, and all the twelve hooks or whirls of the wheel being engaged at once. As the yarns are twisted, they are wound in large bundles upon reels, each wheel containing about two hundred and fifty pounds of yarn.

We must next speak of a distinction between 'white-rope' and 'tarred-rope.' When a rope is to be used in the open air, but under cover, it is left in the 'white' state; that is, it is not coated with tar or any other substance. But when it is exposed to the action of water, a coating of some composition is found necessary to enable the hemp to resist the rotting influence of the water, and tar is the substance almost universally used for this purpose. As regards actual strength, an untarred rope is the stronger of the two; but this is more than counterbalanced by the action of water on the hempen fibre. Propositions have at several times been made to substitute for tar some other composition; but we have here only to speak of the method actually employed.

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The state to which we have now traced our rope is that of a yarn, say one-sixth or one-eighth of an inch in diameter, rough, somewhat uneven, and of a brown colour. This yarn we have next to trace into the form of a 'strand.' As the thickness of yarns is classified according to the number of them required for a three-inch rope, so does the number of yarns combined to form a strand depend altogether on the thickness of rope to be formed. It is this which forms the chief point of difference between different ropes, for the yarns do not vary very greatly in thickness. In the piece of cablet of which we have given a sketch there are only seven or eight yarns in a strand: in a cable twelve inches in circumference there are eighty yarns to a strand; and in the very largest rope-cables ever used in the navy, three hundred and sixty. But whatever be the number, whether as few as seven or as many as three hundred and sixty, they are all twisted uniformly one around another to form a strand. It may be convenient to bear in mind that when the size of a rope is mentioned in inches, it invariably relates to the *circumference*, and not to the *diameter*: thus, a first-rate cable of twenty five-inches is about eight inches in diameter, the larger measurement referring to the circumference.

Here we have to speak of one of the improvements effected by the late Capt. Huddart. When the number of yarns in a strand is very great, a difficulty occurs to which we have before alluded, viz., the unequal strain upon the external and internal parts. About the beginning of the present century Capt. Huddart showed that, in order to equalize the strain, the outer yarns of every strand ought to be somewhat longer than the inner, to compensate for the greater circumference round which they have to turn. He had previously been an officer in the East India Company's service: but he embarked in the undertaking of rope-making chiefly with a view to put in practice certain improvements which his inventive ingenuity had devised; and he thus laid the foundation of the eminent firm which bears his name.

Without detailing the various steps by which improvements were introduced, we will at once proceed to the beautiful machine represented in our frontispiece. In a skeleton frame at one side of the room are a great number of 'bobbins,' each loaded with yarn ready for being formed into a strand, and each being poised on a pivot so as to rotate with facility. The ends of all these yarns, which may be twenty, fifty, eighty, in number, are made to pass through an equal number of small holes in a convex plate attached to the central machine, and then combined into one close group. This group next passes through a tube, whose diameter is such as to compress the yarns into close contact; and lastly, is wound on a large reel attached to the machine. Meanwhile the twist is given to the strand by a remarkable arrangement. The whole of the mechanism, from the tube to the reel, rotates round a horizontal axis, and in so doing imparts a twist to the strand which is passing round the various wheels. The different adjustments are very beautiful. In the first place each bobbin, rotating separately on its axis gives off just as much yarn as the strand requires; so that all become equally strained, by the outer yarns being somewhat longer than the inner. Then the arrangement of the holes in the plate, and of the tube, bring all the yarns to their proper position in the strand; and lastly, by changing the wheels in the machine, the strand becomes more or less hard, by twisting at a more or less acute angle. If the strand be drawn more swiftly through while the machine is revolving with a given velocity, the intensity or closeness of the twist is diminished; if less swiftly, then the twist is increased. The system for attaining any required intensity of twist is called the 'register,' in relation to the means for determining the exact degree of twist in the strand; and hence the whole process has come to be termed, in the technical language of the factory, *registering*.

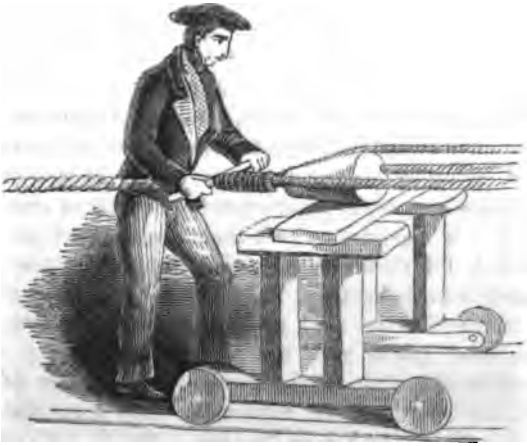
A registered strand, or the strand produced by twisting the yarns together by this machine, is a smooth uniform piece of cordage, all the yarns twisting round in one direction, and all contributing equally to the strength of the whole. Its thickness varies according to the purpose for which it is intended. Thus a strand for a twelve-inch cable contains eighty yarns, and is about an inch in diameter; while that for a smaller rope would be proportionally thinner. The nature of this machine is such that it can produce an endless strand; for if new bobbins are placed on the frame as fast as the old ones are exhausted, and if the strand is removed from the reel as fast as made, the machine, worked as it is by a steam-engine, may continuously add to the length of the strand.

There is another registering-machine of a larger size in the same building, for producing strands of greater diameter. There is also, in that part of the factory called the 'laying-walk,' a curious travelling-engine, which twists the strands of small diameter. At one end of this walk is a bobbin-frame, similar in principle to the one before noticed, and from this the several yarns proceed through a perforated plate, as in the other instance; but instead of being twisted by a machine which revolves on its own axis, the yarns are fastened to revolving hooks attached to a travelling-carriage, which moves on a railway farther and farther from the bobbin-frame as the strand becomes more and more lengthened. The railway extends probably a thousand feet in length; and the machine, which is about a yard long, travels from end to end of this railway in about half an hour, setting in rotation the hooks to which the yarns are attached.

It is not easy for a stranger at first to understand the technicalities of a ropery, for though the word 'twisting' would express the whole succession of steps, yet we hear of 'spinning' when the fibres are twisted into a yarn, 'registering' when the yarns are twisted into a strand, and 'laying' when the strands are twisted into a rope. We must accustom ourselves to the last of these terms in attending to the process next to be described.

In the 'laying-walk' a revolving wheel, placed near one end, is provided with hooks, whereon the three strands to form a rope are fixed (four being sometimes the number, but generally three). These hooks are made to rotate by any of the usual methods, such as turning a hand-winch connected with a wheel which acts on all the hooks, or bringing steam-power into action, both these methods being employed at the factory which is engaging our attention. At the other end of the walk all the strands are fastened to one hook, which revolves in an opposite direction to the others; and it is easy to conceive that this double movement would twist all the three strands round each other. But it is equally easy to see that this twisting would be very unequal, unless other appendages be employed; since the twist would be more close or hard near the ends than at the middle.

Fig. 4. represents the singular contrivance for equalizing the hardness of the twist or 'lay.' A conical or sugar-loaf-shaped piece of wood, called a 'top,' is inserted between the three strands, grooves being cut in the surface of the top for their reception. This top, thus placed, prevents the strands from twisting until they reach a certain


'Laying' or making a Rope.—Fig. 4.

point; while a man, stationed immediately behind, compresses the rope by a simple piece of apparatus, and causes the twist to become hard and firm. The top, as the rope closes behind it, is slowly urged on from one end to the other: if small, it is managed by a 'top-man,' but if large, it is supported on a carriage, as in Fig. 4. No difference exists in the making of a larger or a smaller rope, so far as principle is concerned: the three strands are twisted round each other in the same manner, by apparatus more or less powerful, according to the size of the rope. As it is a natural consequence of the twisting process that the rope should gradually shorten as it is formed, provision is made for this shortening in the arrangement of the apparatus. The wheel to which the three strands are fixed, on three separate hooks, is a fixture at one end of the 'walk;' but the other end of the strands is fastened to a moveable sledge, which is so weighted as to travel gradually up the walk, just as fast as the rope diminishes in length.

A rope thus formed from three strands is the kind which most commonly meets our notice on land, and is technically known as 'hawser-rope,' or 'shroud-rope.' From three such ropes a cable, or cablet, is formed in precisely the same manner; the three being fixed to three revolving hooks at one end, and one at the other; and a travelling 'top' being used to regulate and harden the twist. It may be well to remark, that ropes as ordinarily formed, that is, with three strands, do not require a 'heart,' or central strand, because the angles formed by the union of the three cylindrical strands are such that the pressure, in the operation of laying or closing the rope, causes the strands to fill up the central space completely; but when the number of strands exceeds three, a 'heart' is essential to keep them equidistant from the axis of the rope, and to fill up the vacancy that would otherwise be left by their not meeting in the centre. The heart, however, does not add proportionate strength to the rope, since its fibres, being straighter than those of the outer strands, yield in a different degree.

All arrangements, such as the above, produce ropes of a definite length, viz., the length of the rope-walk. But some machines have been constructed for 'laying' endless ropes, that is, not only effecting all this twisting and hardening by steam-power, but continuing the process to any required extent. For example, in the warehouse of the factory we saw a rope, about eight inches in circumference, and a mile and a quarter in length, which had been made by such a machine.

Of these machines a magnificent series, constructed by the late

Captain Huddart, now occupy a place in Her Majesty's Dock-yard at Deptford: they are for 'laying' cables of the largest dimensions. It is worthy of notice, however, in connection with these details, that iron chain-cables are now superseding hempen cables of large size; the latter being at the present day seldom made more than twelve inches in circumference, except for Her Majesty's Navy. Captain Huddart's cable-laying machines have attracted much attention, from the beauty of their construction. Three or four years ago the Institute of Civil Engineers gave "Telford medals" to two draughtsmen who executed drawings of the whole of the machinery.

One of the upper buildings of the factory contains a powerful and curious machine for making *flat ropes.* These are ropes useful in mining operations, and consist of three or four well-made round ropes stitched together side by side. The operation of making these is simply a gigantic kind of thread-and-needle work; yet the force required renders the employment of a complicated machine necessary. Supposing four round ropes are to form the flat rope, four reels are so placed that the ropes can unwind from them with facility, and pass side by side through a steam-heated box, where the tar becomes a little softened, and the ropes more easily worked. They next pass through a groove or a recess closed in tightly at top, bottom, and sides, except holes at the sides to admit the needles. A piercer, formed of a sharp-pointed rod of steel, probably a foot long and half an inch thick, is then forced entirely through the whole of four ropes, by a leverage of enormous power; and a man immediately afterward passes a needle and thread through the whole. When we say that this thread is a hempen-yarn sometimes half an inch in thickness, it will be readily conceived that the hole for its reception is a tolerably large one, and that no little force is required in drawing the thread tight. Two steel piercers are employed in succession, one on either edge of the rope, making diagonal holes through the four ropes; and two men, provided with needles and thread, pass the latter through the holes as fast as the piercers make them. There is mechanism at one end of the apparatus for drawing the rope forwards as fast as it is sewn. A small part of the arrangement, connected with the more immediate insertion of the needles, is shown in the cut in the next page.

The difference between the varieties of cordage called *twine*, *cord*, *string*, *rope*, &c., is chiefly matter of detail, the actual formation by twisting being nearly the same in all. The finer and lighter kinds of or thirty of these frames or scaffolds ranged parallel one to another, the whole field looks like one mass of flax, extending from the ground to a height of about six feet. Here the flax remains about a week exposed to the air, the action of which, combined with the previous washing and boiling, gives to it a considerable degree of whiteness. Near the bleach-field is a drying-shed, in which the flax is hung up in certain states of the weather. There is also a 'stove-room,' in which the flax can be exposed to any required degree of temperature: this room has an iron floor, through which the heat rises to warm the air of the room; and overhead are poles or bars on which the hanks of flax are hung.

The material being washed, bleached, and dried, we next follow it to some of the inner buildings of the factory, where it gradually assumes the form of woven cloth. All which precedes the actual weaving is effected in one large apartment; and a remarkable apartment this is, both in reference to its general appearance and to the nature of the processes carried on therein. Most persons have a general idea of the nature of woven fabrics, of the long threads, or 'warp,' the short threads, or 'weft,' and the manner in which they mutually interlace. But the preparation of the weft and warp involves a few details not much known beyond the manufacturing districts.

First, for the weft threads. These are used in the shuttle, the movements of which to and fro in the act of weaving form the web. Each shuttle contains a little pivot or axle called a 'quill,' loaded with the weft-yarn; and three or four machines of an ingenious kind are at work in the 'winding-room,'' supplying these quills with yarn. In the old-fashioned process of hand-weaving the quills are filled by women or children, who use a plain wheel to wind the yarn on them. The quill-machines, however, each of which is attended by one woman, have a considerable number of quills ranged in a row, and made to rotate rapidly. In the act of rotation the quills draw off yarn gradually from reels on which it had previously been wound; and the women renew the quills and the reels as fast as the one are filled and the other emptied. A comparison between this operation and that of winding on quills separately, as we saw it being done by a little boy for the hand-loom weavers in another part of the factory, illustrates strikingly the saving of time effected by the former. The little quills in the quill-machine, rapidly revolving and feeding themselves with yarn, require but little care from the attendant, who can manage a whole machine full of them at one time.

remarked the strange medley of sails which the lower classes of vessels display.

Why it is that sails are not made of *broad* canvas, of a width somewhat analogous to that now employed by the floor-cloth manufacturers, we do not know; but the fact is that sail-cloth is woven only to a width of about two feet; so that a large number of joins is required for a large sail. It is not improbable that a greater waste of material would occur in cutting a sail from broad canvas than from that of narrower width, in consequence of the curved and inclined edges of the sails. Be that as it may, the custom seems to have been of long standing and general application, and as such we must view it.

The flax for making sail-cloth is not spun into yarn in London: this process is effected in the flax-manufacturing districts in Scotland, from whence the yarn is purchased for the London market. The yarn comes to the factory in large bundles, made up of smaller hanks or skeins. It is of a light-brownish colour, and has to undergo a washing and partial bleaching process before it is used for sail-cloth. For this purpose the bundles are taken to the 'bucking-house,' a building provided with various coppers, boilers, and large steeping-vessels. The yarn is thrown, in the first place, into hot alkaline liquor, composed of potash or pearlash in hot water, and there steeped for some time. From thence it is removed to a receptacle called a 'splash-mill,' somewhat resembling a fulling-mill, where it is beaten and worked about to free it from impurities. To this succeeds a thorough rinsing or washing in a stream of running water. The water thus imbibed by the yarn is next squeezed out by an hydraulic press; the yarn being put into a box, and pressure being there exerted on it, by which almost every semblance of moisture is expelled. But all this is merely preparatory: for the yarn is next subjected to a five-hours' boiling process, in a copper containing alkaline liquor. All these operations are, as may be supposed, very wet, and not very cleanly; so that the 'bucking-house' is the least attractive part of the factory.

When all that alkaline liquor can remove is thus removed from the hemp, the skeins or hanks are hung out in the open air for several days to dry, and—in the act of drying—to bleach. The 'bleach-field,' as viewed from the summit of the reservoir, has a singular appearance. A series of upright posts support two rows, an upper and a lower, of horizontal poles, on each of which the hanks are hung. As each of these poles runs out to a considerable extent, and as there are twenty or thirty of these frames or scaffolds ranged parallel one to another, the whole field looks like one mass of flax, extending from the ground to a height of about six feet. Here the flax remains about a week exposed to the air, the action of which, combined with the previous washing and boiling, gives to it a considerable degree of whiteness. Near the bleach-field is a drying-shed, in which the flax is hung up in certain states of the weather. There is also a 'stove-room,' in which the flax can be exposed to any required degree of temperature: this room has an iron floor, through which the heat rises to warm the air of the room; and overhead are poles or bars on which the hanks of flax are hung.

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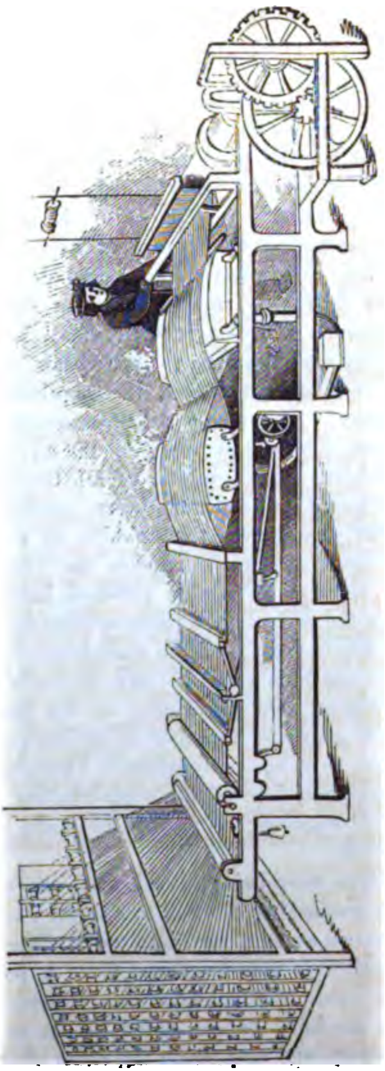
The yarns for the 'warp' are prepared for the weaver with more difficulty. At the entrance-end of the 'winding-room' we see four machines for winding the yarn on bobbins. The skeins of yarn are put on a kind of skeleton wheels about two feet in diameter, from whence they are transferred to bobbins five or six inches long. Here everything seems to be in motion; the wheels or reels on which the skeins are placed, the bobbins for the reception of the yarn, and cylinders or rollers for pressing the yarn close to the surface of the bobbins.

But the most remarkable stage in the proceedings is the next following, of which we have endeavoured to give a sketch in Fig. 6. It is only by closely following the career of a thread through the machine that we can see what processes it undergoes. In the first place, nearly nine hundred bobbins are arranged in an upright frame, so that each one can give off its thread without entanglement with the others. The nine hundred yarns, unwinding from the bobbins, pass through nine hundred little eyes or loops, and then between an equal number of meshes or reeds, to bring all into parallel order. Then the whole nine hundred,



Yarn-dressing and Beaming Machine.—Fig. 6.

XXIII.—A DAY AT A COPPER AND LEAD FACTORY.

Among the three or four public thoroughfares leading from Holborn to Fleet Street, is one wherein the "clinking of hammers" may be heard at all hours of the day, and frequently of the night too. The labours of the "Coppersmith" are in no part of London exhibited on a more extensive scale than in Shoe Lane, the thoroughfare here alluded to, in which are many factories for articles of copper, and also of brass, lead, tin, and other metals. To one of these factories, viz., that of Messrs. E. and W. Pontifex and Wood, we shall direct our attention in the present article.

We may here offer a word of remark on the mode in which many of the manufactures in metal are conducted. All the iron, the copper, the lead, the tin, of which such innumerable articles are manufactured in London, come to the metropolis in a more or less prepared state. The iron, for example, is brought into the state of 'cast-iron' or 'pig-iron' or 'bar-iron,' at the iron-works in Wales, Scotland, or the Midland Counties, and is re-cast or re-forged on a smaller scale in London. So likewise the copper, the tin, and the lead are brought into a purified state at the smelting-works in the country, and converted into the various forms at the London establishments. It therefore often happens that the routine of operations necessary for one kind of metal so nearly resembles that required for another, as to lead to the combination of both under one establishment. This is the case at the factory to which our attention will be here directed, and indeed the combination of trades is here so considerable that a further explanation is necessary. The operations of the firm embrace the entire arrangements connected with the 'fitting-up' of sugar-refineries, distilleries, and breweries, in all of which copper utensils are used on an extensive scale; and the iron and other metal work required is also finished and adjusted at the establishment. The wooden vessels called 'backs' and 'vats,' used in these three branches of manufacture, are likewise made here, as are also lead-pipes and sheet-lead.

shuttle, moves its own assemblage of warp-threads, drives up the weft-threads as fast as they are thrown, and winds the woven canvas on a roller. One woman is able to manage two power-looms, to supply warp and weft, mend broken threads, and remove the finished material.

Besides the power-looms, there are in the factory a considerable number of hand-looms also at work. The semi-scientific exhibitions in London have made these as well as the power-loom tolerably well known; and many a person has probably been surprised at the patience with which a man can sit for hours at a time throwing a shuttle alternately with his right hand and his left, moving a suspended bar alternately to and from him, and treading alternately on a lever with one or the other foot; and many have perhaps pondered how many movements of hand, arm, and foot must be made before a shilling can be earned.

One more process and our sail-cloth is finished. It is taken to a 'receiving-room,' where, after the lumps and irregularities are removed, it is measured and weighed. In one part of the factory is a 'calendering' machine, through which all the canvas then passes. This machine consists mainly of one iron and two wooden rollers, which are made to approximate more or less closely together, according to the pressure intended to be given. The canvas is drawn between these rollers, and comes out flat, smooth, dense, and slightly glossed at the surface. It is then made up into compact parcels, called 'bolts,' in which form it passes into the hands of the sailmaker. Sails are made at this factory, but for the most part the material leaves the establishment in the form of bolts, stamped and numbered.

This rough outline may perhaps have given a general idea of these two branches of manufacture; partially connected in some of their earlier stages, and closely connected in respect of their united importance, to shipping.

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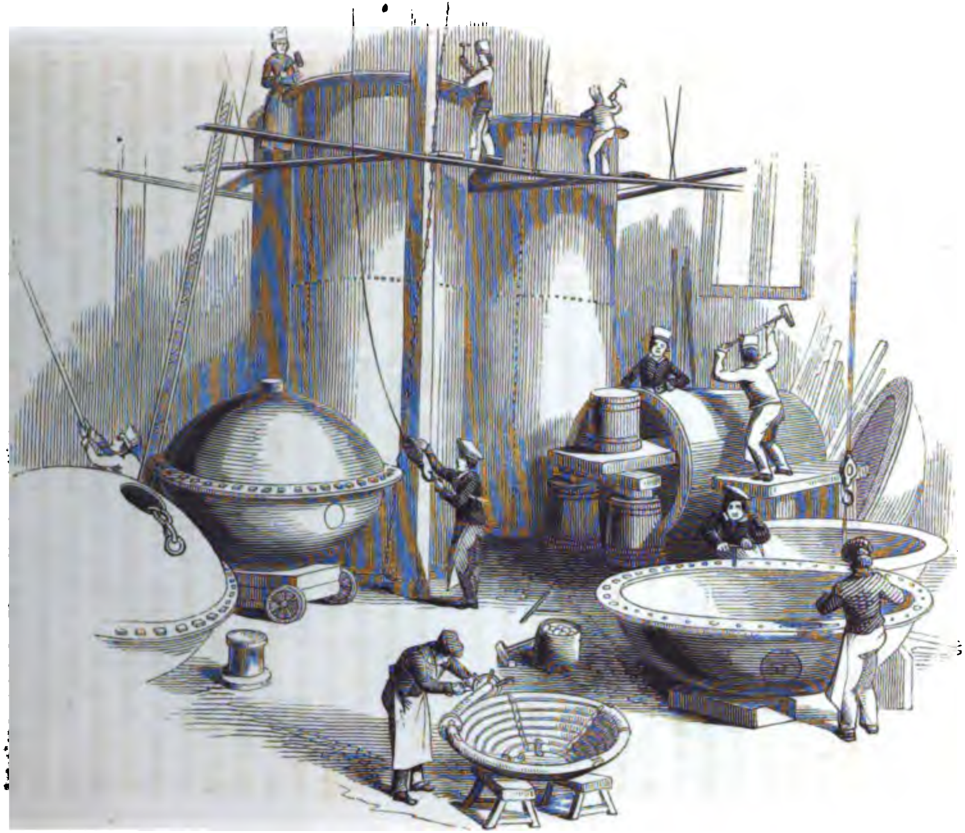


XXIII.—Coppersmith's Shop. Messrs. E. and W. Pontifex's Factory. Face p. 526.

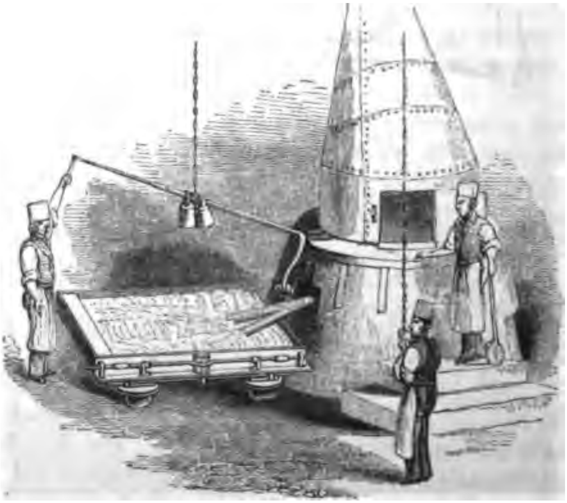
The various trades, therefore, of 'copper-smiths,' 'brass-founders,' 'engine-makers,' 'lead-manufacturers,' 'back and vat makers,' and several others, are all combined by this firm.

Under these circumstances, a detailed account of all the operations would be wholly beyond our range in this article: we shall therefore only give a general description of the factory and its internal economy, together with the operations of the copper, lead, and mixed-metal manufacture.

On proceeding from Holborn to Farringdon Market, through the narrow crooked thoroughfare of Shoe Lane, we come to an open warehouse, on the outside of which are generally cranes, and porters employed in loading waggons with various manufactured articles of lead or copper. Into this warehouse, which immediately adjoins the northern side of the market, we enter, and see around us a mixed assemblage of rolls of lead, coils of pipe, cog-wheels, parts of machinery, and other articles of metal. Before analyzing the dark, the dirty, the busy, the noisy scene which the ground-floor of the factory presents, we will descend a flight of iron steps leading therefrom, and grope our way through a series of underground vaults. These vaults are used principally as store-rooms for metal in the crude and the partially-manufactured state, and exhibit evidences of a very complete system of arrangement. In one department are the 'pigs of lead,' just as they were received from the smelters; in another are 'blocks' of tin, ready to be melted and worked; in other departments are all the various pieces and parts for pumps, engines, machines, &c., either cast in the foundry on the premises, or brought from foundries in the iron districts. Every room or vault is surrounded by shelves or drawers, every shelf is marked, and every piece of metal, even to the smallest screw or nut, deposited in its proper compartment, and registered in a book. The superintendent of this department, who conducts his operations by lamp-light, receives from the founders these multifarious pieces, and delivers them to the foremen of the works upstairs when wanted for manufacturing purposes. Many hundred tons of metal, comprising iron, copper, brass, gun-metal, tin, and lead, are here deposited.

In these cellars, too, is situated the opening of a very deep Artesian well, bored a few years ago for the use of the factory. It is excavated to about the depth of one hundred feet, and then bored to the extent of another hundred; and is worked by the steam-engine employed for various other operations upstairs. Those who are acquainted with by pouring the melted metal on a flat surface of sand, in a stratum of any required thickness. But the method pursued at the factory under notice is the more modern one of rolling, or 'milling,' which we proceed to describe.

A furnace is provided, consisting of a hemispherical melting-pot, four or five feet in diameter, and nearly as much in depth, heated by a fire beneath, and covered with an enclosed cap or chimney reaching above the roof of the building, for the purpose of conveying away the deleterious gases engendered during the melting of lead. Into this melting-pot is put about six tons (thirteen thousand pounds) of lead, new and old, which remains there till thoroughly melted. During this time all the impurities, being lighter than the metal, rise to the surface. Immediately adjoining the furnace is a cast-iron frame called the 'mould,' being a flat vessel about six or seven feet square and six inches deep. The bottom of this mould is also of iron, and the melted metal is allowed to flow into it, along a trough or shoot, from an open valve near the bottom of the melting-pot. Fig. 2 represents this operation. The glistening liquid mass soon flows out, to the weight of ten or eleven thousand pounds, the dross and impurities being for the most part left behind in the melting-pot. As, however,



Lead Foundry.—Fig. 2.

ments whereby the pipes, thus cast, are elongated and made ready for use.

From this department we cross over to that devoted to the copper-manufacture; and here such is the din and clatter, that a stranger finds it no easy matter to collect his ideas and see what is going forward. Men wielding large hammers are on every side fashioning vessels and articles of copper: here a sugar-pan, there a sugar-filtering cylinder, in one place a boiler, in another a copper, in a third a still, in a fourth a worm. The metal being very sonorous, and being held on an iron anvil while struck by an iron hammer, yields sounds much more strong than musical. On one side are forges for heating the metal necessary for soldering, or, as it is more generally termed, 'brazing,' such articles of copper as cannot be joined by rivets; and here and there are small, open, temporary forges, employed for annealing the copper during the progress of the manufacture. Some of the huge vessels seen in this part of the building exemplify in a striking degree the modern improvements in the mode of conducting the sugar-refinery, for which the vessels are intended: this is especially exemplified by the large clarifying cylinders now occasionally used in a certain stage of the sugar-manufacture, some of which are sixteen feet in height. Our frontispiece represents a part of the busy assemblage presented in this 'copper-shop;' most of the vessels seen being connected in some way or other with the sugar-refinery, but others pertaining to the distilling or brewing. The lofty cylinders here seen, as well as other parts of the copper apparatus, were for an extensive sugar-refinery, which, at the period of our visit, was being constructed by the firm at St. Petersburg. This may illustrate one of the peculiar manufacturing features of the present day; where English firms not only fit up our home manufactories, but also undertake the construction and arrangement of factories in almost every country on the globe. In the present case, for example, the firm whose factory we are here describing had undertaken the entire manufacturing arrangements for fitting up a new sugar-refinery in Russia. The plan had been furnished for the guidance of the Russian builders, while the machinery was being made here. There were ten of these enormous copper-cylinders, six 'blow-up' cisterns, also of copper, six copper filtering-vessels of a peculiar construction, vacuum-pans, coolers, cisterns, moulds, and all the varied apparatus for a sugar-refinery. The mechanism and vessels, when completed, were sufficient to freight a 700-ton ship to St. Petersburg.

In the ground-story are also the 'foundry' and the 'smithery,' which, like the parts just described, require a solid foundation for the heavy furnaces, &c., contained therein. The 'foundry' contains all the arrangements for casting small works in brass, in bell-metal, in gun-metal, and in other mixed metals of which copper, zinc, lead, and tin are the component ingredients. The melting-furnaces, sunk below the level of the ground, the sand-moulds for casting, and other parts of the arrangements, bear a considerable resemblance to those presented in the bell-foundry noticed in another page. Here, too, is an air-furnace, for use in cases where an intense heat is required. The 'smithery' presents the usual assemblage of forges, anvils, and other apparatus necessary for the forging of iron. Nearly all the wrought-iron required in the mechanism fitted up at the factory is forged in this 'smithery.'

Among the mechanical arrangements for facilitating the removal of heavy goods from one part of the factory to another, we noticed an ingenious railway fixed *near the ceiling or roof*, whereby boilers, coppers, stills, engines, &c., suspended from a wheeled carriage or frame, could be easily moved along above the head of the workmen without disturbing the manufacturing arrangements beneath. This contrivance arose out of the necessity for economizing space, but we are inclined to think that it might he advantageously employed under many other circumstances in large factories.

Let us now pass upwards from the ground-floor, and glance through the upper ranges of shops. The front portion of the first floor is occupied chiefly as a warehouse for finished goods in copper, gun-metal, lead, &c. Here, too, are the various offices and counting-houses, and also a room appropriated to the draughtsmen. In the fitting-up of large factories, such as sugar-refineries and distilleries, there are, as may be supposed, many drawings of plans, sections, elevations, diagrams, &c., necessary not only for making a contract and showing the proposed action of the whole machinery, but as working drawings for the guidance of the workmen. The preparation of such drawings is effected in the office here alluded to, where labelled drawers are devoted to the reception of different classes of drawings.

Behind the ware-rooms and offices extends a long apartment, having windows all along both sides, and benches immediately beneath them: this busily-occupied room is the 'brazier's shop.' The 'pattern-room' is another of those which exhibit the advantages of systematic arrangement in a large factory. This room is fitted up with cases, shelves, and boxes, filled with patterns in wood, clay or metal, of the various pieces required to be cast in the foundry below. Every pattern, large and small, is numbered or ticketed, so as to be readily found when wanted. To let everything "have its place and be in its place," is the simple but valuable principle on which alone the operations of such establishments as these can be kept free from confusion.

Above the floor just visited is a warehouse for unfinished or partially manufactured goods; and a long shop for the 'back and vat makers.' If we were to speak of 'cisterns and tubs' we should convey a much more definite idea to the minds of general readers, than by using the technical names 'backs and vats;' but the truth is that each large branch of manufacture has almost a language of its own, the workmen seeming to delight in having a phraseology unintelligible to others. Thus, the brewer's 'liquor-back' is to all intents and purposes a 'water-cistern;' yet not only are the two words 'water' and 'cistern' not used in a brewery, but in some breweries a fine is imposed, and insisted on by the men, on those who may happen to use the plain English words. We make this remark here as the best mode of explaining that a 'back' is the technical name for large wooden cisterns or vessels employed in distilling and similar operations; and that a 'vat' is a tall wooden tub or open cask. The manufacture, which to a small extent is carried on in this range of shops, is a superior kind of cooperage.

The remaining workshops of the factory are occupied by millwrights, machine-makers, pump-makers, and others employed in fitting up and putting together the various pieces of metal which, after being cast and forged elsewhere, are employed for the construction of machines and other apparatus. To enumerate all these various machines would be here both impracticable and unnecessary: they are of all degrees of complexity, from a water-cock to a steam-engine, and of various kind of metal. But we may observe that one of these workshops extends a hundred and fifty feet in length; and along the entire extent of the room, just below the ceiling, and midway between the sides, is a roller or hollow cylinder, kept in rotation by a connecting band from the steam-engine beneath: this, as a source of power, sets in motion a large number of lathes, drilling-machines, screw-cutting machines, &c., placed beneath. In this room all articles of brass, gun-length increased. Again and again is the pipe, with its contained mandril, drawn along the frame; the die being exchanged after each drawing, and replaced by one of smaller diameter. In producing a two-inch pipe no fewer than sixteen dies are employed, the diameters of which descend in a regular series. The hole through the die is conical, that is, larger on one side of the die than on the other; and the lead enters the hole at the widest part, whereby a process of compression is undergone: but at a certain point in the operations a 'cutting-die' is introduced, that is, one wherein the lead is at once exposed to a cutting-edge, the result of which is, that a thin film is cut or scraped from the whole surface of the pipe. By the time that all this routine is undergone the metal has become more dense and compact, the temperature so high as scarcely to be bearable by the hand, the length greatly increased, and the external diameter proportionably diminished. After this the elongated pipe is removed from the mandril, and is then ready for disposal to the plumber.

Let us now turn our attention to those operations which exhibit the chief features of the

COPPER MANUFACTURE.

So far as regards the factory under our notice, copper is a more important metal than lead: but we have given precedence to the latter simply as a matter of convenience, because many of the early processes in the copper manufacture may be more readily understood by comparing them with those in lead.

When we find that all copper vessels, and indeed almost all the more important articles made of copper alone, are formed from sheet-copper, it may naturally be asked how these sheets are produced, and whether or not they are made at the London factories. To answer these questions we must point out the difference between the operations of the copper-miner, the copper-smelter, the copper-mill owner, and the copper-smith. The copper-miners, principally at the very western extremity of Cornwall, extract the ore from the metalliferous veins underground, bring it to the surface, and subject it to a slight preparatory process. The copper-smelters then purchase the ore in this state, and take it to the smelting-works, most of which are near Swansea in Wales, and there, by exposure to powerful furnaces, separate the copper from the other metallic and earthy substances with which it was combined. The form into which the copper is brought by the smelters is that of square pieces called 'tiles,' measuring nine as this will aid in the subsequent details relating to copper.

All brass-founders, bell-founders, iron-founders, lead-manufacturers, and similar workers in metal, are desirous of obtaining *old* metal to mix with new. So it is likewise with the glass manufacturers, who mix 'cullet,' or broken glass, with the flint and alkali for forming new glass; and also broken crucibles in the manufacture of new ones. The old ingredient gives to the new certain valuable qualities not possessed by the latter when used singly; perhaps because the old material has acquired a better amalgamation, a more complete union of its parts, whether it be a metal, or glass, or baked earthenware. Be this as it may, old lead-pipe, old sheet-lead, old copper-sheathing from ships, old copper-boilers, old bells—all are bought by the respective founders, to be employed in the construction of new articles.

As the amount of old material is, of course, far beneath the quantity required, we have to speak of the form in which the new metal is brought to the factory. In the case of *lead*, the new metal is brought to London in the form of 'pigs,' each of which is an oblong mass, about three feet long, six inches wide, and weighing about one hundredweight and a half. As for the philosophy of the word 'pig,' applied to the masses of lead, we may remark that it forms another curious instance of the phraseology alluded to in a former paragraph. It appears that in the iron-manufacture, when the metal flows from the furnace in which it has been reduced from the ore, it passes into a large trough excavated in sand, and from thence into smaller lateral channels on each side. This arrangement has been suggestive of a sort of simile: for the larger trough is called by the workmen the 'sow,' and the smaller the 'pigs,' who suck the metal from the sow: hence proceeded the names of 'sow-metal' and 'pig-metal,' and hence, in all probability, the name of 'pig,' as applied to the saleable masses both of iron and of lead.

The two principal articles into which lead is manufactured are *sheet-lead* and *water-pipes*—or at least they are the only two which need here be noticed—since the comparatively low temperature at which the metal fuses, and the ease with which it is beaten into various forms, enable the plumber to modify it in various ways. The sheet-lead here spoken of is that with which roofs and terraces are covered and cisterns lined. It is sometimes made, and used formerly to be wholly made, piece of copper which had been dished or hollowed in this way, and which, though worth forty guineas if sound, was rendered useless by a flaw in the metal.

The curved piece of copper just spoken of receives its form from the tilt-hammers at the copper-mill, and then passes into the hands of the copper-smith for the subsequent operations. The top and the bottom of the 'sugar-pan' receive their form in a similar way; but many smaller pieces have to be added in order to complete the vessel. The side is a portion of a cylinder, made of sheet-copper, and rivetted at the edge. One of the most noisy operations in a copper-smith's shop is the hammering which the copper receives in order to render it dense and firm. The piece of copper is supported on an anvil or iron bed, and beaten with hammers in every part, whereby the particles of the metal are brought into more dense and compact union, and an additional degree of toughness is imparted. The ringing and clanging which this produces in a piece of sheet-copper perhaps seven or eight feet in diameter is to a stranger almost deafening. The name applied to the process is 'planishing;' and where the surface of the copper is very large, the operation has something of the picturesque effect presented by the anchor-smithery; for six or eight men, standing in a circle round the piece of copper, and each wielding a heavy hammer, strike the metal in succession, every part of the surface receiving probably as many as ten or twelve blows. Any one who examines a large copper vessel will see evidences of this 'planishing' process, not only by the hammer-marks, but by the density and 'close grain' of the surface.

An important part of the operations is that connected by the rivetting or fastening of the joints. This is effected by making one edge overlap the other, and by passing a rivet through them, the point or small end of the rivet being afterwards hammered down. Hence arise three steps in the process—viz., the punching of the holes for the reception of the rivets, the making of the rivets themselves, and the process of rivetting. The punching-engine consists principally of a long lever, to the shorter arm of which is attached a punch corresponding to the size of the hole to be made, and generally of a cylindrical shape. The piece of copper is brought to the engine, and placed between the punch and the support beneath, so adjusted as to cause the punch to act upon the exact spot where the hole is to be made. A pressure of the lever causes the punch to descend on the copper, and to cut out a small circular piece corresponding with the required size of the hole. The piece of copper is then shifted onward through a small space, and another hole similarly made; and so on to the required extent.

In the process of rivetting, each rivet, which is made at the forge, is passed into the hole bored for its reception, and the point or small end of the rivet is hammered down close to the sheet-copper, so as to clasp it very tightly, having in fact a head or stay within and without. The edge of the copper is then 'caulked,' that is, hammered so as to bring the two surfaces of the joint into very close contact, forming a bond so intimate as to resist the passage of water, air, or steam.

Several of the openings into a sugar-pan, or indeed into other copper vessels used in manufactures, are not simply holes cut in the sheet-metal, but have collars or edges made of cast-metal, whereby the fastening can be effectually secured. These various pieces—the technical names for which need hardly be given here—are cast in sand in the usual manner, and are afterwards turned and finished by other means.

The coil of steam-pipe which occupies the lower part of the interior of a sugar-pan, as a means of heating the sugar to be contained therein, involves operations of a different kind from those hitherto described. This coil usually consists of pipe about three inches in diameter, but much thinner than the same diameter of lead-pipe would be. In order to form it a strip of copper is taken, as long as may be conveniently obtained, and rather wider than the circumference of the intended pipe. The two edges of this strip are bent upwards, to give the first semblance of a curve; and the piece is then passed through the holes or 'dies' of the tube-drawing machine, by which it is made perfectly cylindrical, with one edge slightly lapping over the other. The joint thus made is secured by a process of soldering or brazing, aided by heat in the usual manner. Soldering or brazing, it may perhaps hardly be necessary to state, depends for its action on the different temperatures at which different metals melt. Thus, to join two pieces of lead, a mixed metal, or 'solder,' is employed which melts and acts as a cement at a temperature that will not injure the lead. So, in like manner, two pieces of copper are joined or 'brazed' by using a mixed metal partaking of the nature of brass, which remains fluid at a temperature not high enough to injure the copper. A small forge or brazing-furnace is employed to heat the metals, and borax is employed to facilitate the fusion of the brass.

Thus far the operations for making a copper-pipe are apparently simple: but the mode of bringing the straight pipe into the form of a coil is very curious. Any attempt to bend a pipe in this manner, so long as the metal is thin and the pipe empty, would be accompanied by the distortion of the sectional area of the pipe, originally circular, and perhaps by fracture. To obviate this, therefore, the interior cavity of the pipe is entirely filled up, either with lead, or with some composition which will melt and flow at a temperature not likely to injure copper. This being effected, the pipe becomes solid, and may then be bent without disturbing its shape, by the application of sufficient power. By a simple machine, downward pressure is exerted on the pipe at one part, while upward pressure is exerted on the adjoining parts, whereby the pipe is gradually coiled round into a form nearly resembling that of a common tea-saucer, fitted to lie in the bottom of the sugar-pan. By the application of heat on a temporary stove beneath, the interior composition is melted out, and the vacancy restored. The strength of the tube is tested by exposure to steam of high pressure for several days; various minor adjustments are effected; and the coil is inserted in the sugar-pan.

Nearly all the vessels manufactured by the copper-smith are produced by various modifications of the processes here noticed. Cutting, hammering, rivetting, planishing, brazing—these are the principal operations performed. If we were to select any other article, and trace it through the successive processes, we should find it, so far as mere description goes, little else than a repetition of the above details. There are, however, some exceptions to this statement, which we may here notice.

In the process of hammering the plates or large surfaces of copper the hammered surface becomes hardened; and to remedy this, the copper is exposed to a strong heat for a certain time, and then plunged into water, by which an oxide is removed and the copper softened. For large sheets, this process of annealing is effected on a flat stove about three feet from the ground, the stove being covered with burning fuel, and the copper laid thereon. A cistern of water is kept beneath the floor of the shop, near the stove, into which the heated copper is suddenly plunged, as a means of removing the external oxide. For smaller pieces temporary stoves or fires are adjusted in any convenient part of the shop, a draught being ingeniously supplied by a current of air forced through a flexible tube by the action of the steam-engine.

This process of annealing is not effected in connection with the 'planishing,' but with that hammering whereby the shape of a curved piece of copper is produced. Let us suppose, for instance, that a hemispherical copper cup, a foot in diameter, is to be produced. A circular piece of copper, considerably more than a foot in diameter, is selected, laid on a sort of small convex anvil and hammered in such a manner as to make the upper surface gradually convex. This is effected by a peculiar action of the hammer, whereby the metal is as it were driven from the centre towards the circumference, and gradually curled or turned up. But it happens that, after a certain amount of hammering, the copper becomes so hard as to be in danger of fracture; and it is to remove this hardness that the 'annealing' is effected. In one of the shops of the factory is an ingenious machine for producing the curvature of a piece of copper, in which the copper is worked to and fro between two small wheels or rollers, placed in more or less close approximation, according to the pressure required.

The manufacture of copper-plates for engravers, one of the departments carried on within this building, will illustrate the means adopted for producing a level and brilliant polished surface of copper. The copper is, in the first instance, cut to the required size from a plate of the best and soundest quality; and is then scraped all over with a steel instrument to remove any slight defects that may exist at the surface. The workman occasionally holds a piece of oiled paper between the window and the plate, whereby a peculiar light falls on the latter, calculated to render the minutest flaws or defects visible. When scraped sufficiently, the plate is taken to an anvil and well hammered, to render it more dense and also to flatten it. The surface is then well ground with a kind of hard blue stone wetted with water; and finally polished with fine charcoal, by which all the marks from the scraping, hammering, and grinding are removed. When it is considered that the finest lines produced by the graver must be made perfectly distinct and clearly marked, it may well be supposed that the surface is required to be free from scratches and imperfections of every kind.

Of the sugar-moulds, the clarifying-vessels, the stills and other vessels employed by distillers, the coppers for brewers, the copper-baths, the copper-boilers, and other vessels made of this metal, we shall refrain from saying more here. All are made of sheet-copper, all are hammered and annealed, and all are either riveted more or less extenpiece of copper which had been dished or hollowed in this way, and which, though worth forty guineas if sound, was rendered useless by a flaw in the metal.

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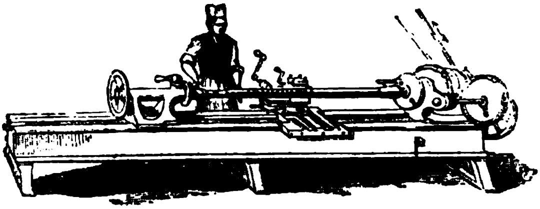

Screw-cutting Lathe.—Fig. 7.

mechanism is at the same time so extensive and so delicate, that it will cut a screw whose threads are eight inches apart, or one which has a hundred threads to the inch, or one having any intermediate number between these wide extremes. The principle of the machine rests on the combination of two movements—a rotatory motion of the bar to be cut into a screw, and a longitudinal motion of the cutting tool; and the distance between the threads of the screw depends on the ratio between the velocities of these two movements.

We stated, in the commencement of this article, that our description of processes must be confined to two or three branches, being those forming the chief features of this establishment. As a "copper and lead factory" we proposed to notice it; and this we have done.

We have in general made a point of avoiding all allusions to the private economy of manufactories, further than regards the processes carried on therein; but there is one point on which we will here offer a few remarks. It must be obvious that where some hundreds of men are employed, some working by the day, and others by 'piece-work,' and where scores of different materials are used, the commercial accounts of a factory must require extreme care and a well-organized system, to prevent the most inextricable confusion. A merchant who imports foreign produce to sell again at a profit, has comparatively an easy task in booking his transactions; but the manufacturer who makes an engine, consisting of many scores or even hundreds of parts, some of one metal and some of another, and made by men of whom some are paid by the day and others by the piece, has a task of no mean difficulty in estimating the actual cost of a machine. We have had an opportunity of observing the system pursued in the factory to which this chapter relates, and have been much struck with the elaborate, but yet simple, principle of checking all the accounts. Every piece of copper, brass, &c., is weighed when given by the store-keeper to the foreman of the works; every order has a symbol attached to it, not only on the books, but also stamped on the principal pieces of metal employed; the mode in which every hour of every man's time has been employed is strictly ascertained, in connection with the symbols attached to the respective orders; the 'time' of each workman is so ascertained and recorded that an error can hardly occur; and the wages and materials are so classed as to afford ready means of reference at any subsequent time. The details of the system we of course cannot enter into; but we may remark, that a period of six or eight years is stated to have elapsed in bringing the system, by gradual stages, to the degree of completeness necessary for the complicated operations of the factory.

THE END.

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